JOURNAL OF COMPUTATIONAL PHYSICS **123,** 233 (1996)
ARTICLE NO. 0020

Abstracts of Papers to Appear in Future Issues

ALGEBRAIC LIMITATIONS ON TWO-DIMENSIONAL HYDRODYNAMICS SIMULATIONS. Paul P. Whalen, *Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.*

Algebraic limitations imposed by the use of connected straightline segments to define meshes for hydrodynamics simulations in two-dimensional cylindrical geometries are shown. It is shown that in the simplest smooth isentropic flow of the spherical expansion of a gas with point symmetry, commonly, and currently, used finite difference, finite volume, or finite element staggered grid hydrodynamics equations cannot simultaneously preserve energy, entropy, and sphericity on an equal-angle $R - \Theta$ mesh. It is further shown why finite difference codes tend to preserve sphericity and entropy, while finite element codes tend to preserve sphericity and energy. Exact difference representations of interface (cell face) pressures and work terms and of the elements of the strain rate tensor in a cell are shown.

MULTIDIMENSIONAL QUADRATURE ALGORITHMS AT HIGHER DEGREE AND/OR DIMENSION. Simon Capstick, *Supercomputer Computations Research Institute and Department of Physics, Florida State University, Tallahassee, Florida 32306, U.S.A.;* B. D. Keister, *Physics Division, National Science Foundation, 4201 Wilson Boulevard, Arlington, Virginia 22230, U.S.A., and Department of Physics, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, U.S.A.*

The accuracy of two multidimensional quadrature algorithms is examined with some simple test integrals. It is found that a scheme introduced by Genz is considerably more accurate and is simpler to implement for higher degree and/or dimension than one due to McNamee and Stenger.

THE GEOMETRIC SOLUTION OF LAPLACE'S EQUATION. Ezzat G. Bakhoum, *ESD Research Corporation, P.O. Box 2818, Durham, North Carolina 27715, U.S.A.;* John A. Board, Jr., *Department of Electrical Engineering, Duke University, Durham, North Carolina 27706, U.S.A.*

A new numerical method for the rapid solution of Laplace's equation in exterior domains and in interior domains with complicated boundaries is presented. The method is based on a formula first stated by J. J. Thomson and later refined by the authors. The mathematical foundations presented allow for the solution of field problems by means of geometric construction principles. Specifically, the method utilizes the concept of representing equiporential surfaces by polynomials for the rapid tracing of these surfaces and is, therefore, fundamentally different from previously known techniques which are based on discretizing the domain or the boundary of the problem. For the class of problems characterized by irregular domains, the fastest available techniques have traditionally required an $O(M \cdot N)$ computation, where M is the number of points inside the domain at which the solution is computed and N is the number of points used on the boundary. The new method requires an $O(M)$ computation only and is, therefore, more advantageous in large scale calculations. This paper presents only the two-dimensional version of the geometric solution of Laplace's equation.

A DYNAMIC MESH ALGORITHM FOR CURVATURE DEPENDENT EVOLVING INTERFACES. R. H. Nochetto, *Department of Mathematics and Institute for Physical Science and Technology, University of Maryland, College Park, Maryland 20742, U.S.A.;* M. Paolini, *Dipartimento di Matematica, Università di Milano, 20133 Milan, Italy, and Istituto di Analisi Numerica del CNR, 27100 Pavia, Italy;* C. Verdi, *Dipartimento di Matematica, Università di Milano, 20133 Milan, Italy.*

A new finite element method is discussed for approximating evolving interfaces in $\mathbb{R}^n$ whose normal velocity equals mean curvature plus a forcing function. The method is insensitive to singularity formation and retains the local structure of the limit problem and, thus, exhibits a computational complexity typical of $\mathbb{R}^{n-1}$ without having the drawbacks of front-tracking strategies. A graded dynamic mesh around the propagating front is the sole partition present at any time step and is significantly smaller than a full mesh. Time stepping is explicit, but stability constraints force small time steps only when singularities develop, whereas relatively large time steps are allowed before or past singularities, when the evolution is smooth. The explicit marching scheme also guarantees that at most one layer of elements has to be added or deleted per time step, thereby making mesh updating simple and, thus, practical. Performance and potentials are fully documented via a number of numerical simulations in 2D, 3D, 4D, and 8D, with axial symmetries. They include tori and cones for the mean curvature flow, minimal and prescribed mean curvature surfaces with given boundary, fattening for smooth driving force, and volume constraint.

STABILITY ANALYSIS OF OPERATOR SPLITTING FOR LARGE-SCALE OCEAN MODELING. Robert L. Higdon, *Department of Mathematics, Oregon State University, Corvallis, Oregon 977331-4605, U.S.A.;* Andrew F. Bennett, *College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon 97331-5503, U.S.A.*

The ocean plays a crucial role in the earth's climate system, and an improved understanding of that role will be aided greatly by high-resolution simulations of global ocean circulation over periods of many years. For such simulations the computational requirements are extremely demanding and maximum efficiency is essential. However, the governing equations typically used for ocean modeling admit wave velocities having widely varying magnitudes, and this situation can create serious problems with the efficiency of numerical algorithms. One common approach to resolving these problems is to split the fast and slow dynamics into separate subproblems. The fast motions are nearly independent of depth, and it is natural to try to model these motions with a two-dimensional system of equations. These fast equations could be solved with an implicit time discretization or with an explicit method with short time steps. The slow motions would then be modeled with a three-dimensional system that is solved explicitly with long time steps that are determined by the slow wave speeds. However, if the splitting is inexact, then the equations that model the slow motions might actually contain some fast components, so the stability of explicit algorithms for the slow equations could come into doubt. In this paper we discuss some general features of the operator splitting problem, and we then describe an example of such a splitting and show that instability can arise in that case.

0021-9991/96 $12.00