JOURNAL OF COMPUTATIONAL PHYSICS 114, 350 (1994)

Abstracts of Papers to Appear in Future Issues

AN IMPLICIT–EXPLICIT EULERIAN GODUNOV SCHEME FOR COMPRESSIBLE FLOW. J. P. Collins. *Information and Mathematical Sciences Branch, Naval Surface Warfare Center, White Oak, Silver Spring, Maryland 20903, U.S.A.*; P. Colella. *Mechanical Engineering Department, University of California, Berkeley, California 94720, U.S.A.*; H. M. Glaz. *Department of Mathematics, University of Maryland, College Park, Maryland 20742, U.S.A.*

A hybrid implicit–explicit scheme is developed for Eulerian hydrodynamics. The hybridization is a continuous switch and operates on each characteristic field separately. The explicit scheme is a version of the second-order Godunov scheme; the implicit method is only first-order accurate in time but leads to a block tridiagonal matrix inversion for efficiency and is unconditionally stable for the case of linear advection. The methodology is described for the cases of linear advection, for nonlinear scalar problems, and for gas dynamics. An important element of our work is the use of a modified Engquist–Osher flux function in place of the Godunov flux. Several numerical results are presented to demonstrate the properties of the method, especially stable numerical shocks at very high CFL number and second-order accurate steady states.

SYMBOLIC–NUMERICAL METHOD FOR THE STABILITY ANALYSIS OF DIFFERENCE SCHEMES ON THE BASIS OF THE CATASTROPHE THEORY. E. V. Vorozhtsov, B. Yu. Scobelev, and V. G. Ganzha. *Institute of Theoretical and Applied Mechanics of the Russian Academy of Sciences, Novosibirsk 630090, Russia.*

We propose a symbolic–numerical method for the stability analysis of difference initial-value problems approximating initial-value problems for the systems of partial differential equations of hyperbolic or parabolic type. The basis of the method is constituted by the Fourier method. It is proposed to use the catastrophe theory for an analysis of the manifold of characteristic equation zeros. This equation is derived automatically by symbolic computations which also enables us to automatically generate some FORTRAN subroutines needed for the analysis within the framework of the catastrophe theory. Examples of the application of the developed method are presented. In particular, the necessary stability condition has been obtained for the two-cycle MacCormack scheme of 1969.

OPEN BOUNDARY CONDITIONS IN THE SIMULATION OF SUBSONIC TURBULENT SHEAR FLOWS. Fernando F. Grinstein. *Laboratory for Computational Physics and Fluid Dynamics, Code 6410, Naval Research Laboratory, Washington, DC 20375-5344, U.S.A.*

Dealing with open boundaries in the computer simulation of unsteady subsonic shear flows presents challenging problems. In practice, only a portion of the flow can be investigated and we must ensure that the presence of artificial boundaries does not pollute the solution in a significant way. One difficulty is related to the basic solution of the physical flow equations and involves choosing appropriate nonlocal open boundary conditions at the outflow boundaries which will adequately bound the computational domain while providing information about the virtual flow behavior outside. A second difficulty is related to the discretized computational problem, for which additional numerical boundary conditions that are consistent with the unsteady flow equations at the boundaries are required for closure. Recent approaches based on characteristic analysis and their practical implementation are discussed. Specific examples are used to illustrate the implementation of state-of-the-art approaches to open boundary conditions and, in particular, the potential sensitivity of subsonic free shear flows to the actual choice of open boundary conditions. This sensitivity is an intrinsic feature of the flows being studied rather than an artifact of the computations. *Ideal* free shear flows do not exist; actual flow realizations are defined by the numerical or laboratory boundary conditions in the experiments.

AN EXPONENTIALLY FITTED FINITE VOLUME METHOD FOR THE NUMERICAL SOLUTION OF 2D UNSTEADY INCOMPRESSIBLE FLOW PROBLEMS. John J. H. Miller. *Department of Mathematics, Trinity College, Dublin 2, Ireland*; Song Wang. *Tritech, 26 Temple Lane, Dublin 2, Ireland.*

In this paper we first develop and test an exponentially fitted finite volume method for the numerical solution of the Navier–Stokes equations describing 2D incompressible flows. The method is based on an unstructured Delaunay mesh and its dual Dirichlet tessellation, combined with a locally constant approximation to the flux. This yields a piecewise exponential approximation to the exact solution. Numerical tests are presented for a linear advection–diffusion problem with boundary layers. The method is then applied to the driven cavity problem with Reynolds numbers up to 10^4. The numerical results indicate that the method is robust for a wide range of values of the Reynolds number. In the case $Re = 10^4$ unsteady solutions are captured if the mesh is sufficiently fine.

A SPECTRAL ELEMENT--FCT METHOD FOR THE COMPRESSIBLE EULER EQUATIONS. John Giannakouros and George Em Karniadakis. *Department of Mechanical Aerospace Engineering, Program in Applied and Computational Mathematics, Princeton University, Princeton, New Jersey 08544, U.S.A.*

A new algorithm based on spectral element discretizations and flux-corrected transport concepts is developed for the solution of the Euler equations of inviscid compressible fluid flow. A conservative formulation is proposed based on one- and two-dimensional cell-averaging and reconstruction procedures, which employ a staggered mesh of Gauss–Chebyshev and Gauss–Lobatto–Chebyshev collocation points. Particular emphasis is placed on the construction of robust boundary and interfacial conditions in one- and two-dimensions. It is demonstrated through shock-tube problems and two-dimensional simulations that the proposed algorithm leads to stable, non-oscillatory solutions of high accuracy. Of particular importance is the fact that dispersion errors are minimal, as shown through experiments. From the operational point of view, casting the method in a spectral element formulation provides flexibility in the discretization, since a variable number of macro-elements or collocation points per element can be employed to accomodate both accuracy and geometric requirements.

0021-9991/94 $6.00