JOURNAL OF COMPUTATIONAL PHYSICS 89, 251-256 (1990)

Abstracts of Papers to Appear in Future Issues

NEWTON'S METHOD APPLIED TO FINITE-DIFFERENCE APPROXIMATIONS FOR THE STEADY-STATE COMPRESSIBLE NAVIER-STOKES EQUATIONS. Harry E. Bailey and Richard M. Beam, *NASA Ames Research Center, Moffett Field, California, USA.*

Newton's method is applied to finite-difference approximations for the steady-state compressible Navier-Stokes equations in two spatial dimensions. The finite-difference equations are written in generalized curvilinear coordinates and strong conservation-law form and a turbulence model is included. We compute the flow field about a lifting airfoil for subsonic and transonic conditions. We investigate both the requirements for an initial guess to ensure convergence and the computational efficiency of freezing the Jacobian matrices (approximate Newton method). We consider the necessity for auxiliary methods to evaluate the temporal stability of the steady-state solutions. We demonstrate the ability of Newton's method in conjunction with a continuation method to find nonunique solutions of the finite-difference equations, i.e., three different solutions for the same flow conditions.

INADEQUACY OF FIRST-ORDER UPWIND DIFFERENCE SCHEMES FOR SOME RECIRCULATING FLOWS. A. Brandt, *The Weizmann Institute of Science, Rehovot, ISRAEL*; Irad Yavneh, *Los Alamos National Laboratory, Los Alamos, New Mexico, USA.*

Spurious numerical solutions of problems with closed sub-characteristics by upwind difference schemes, in particular problems of recirculating incompressible flow at high Reynolds numbers, are proved to be due to the anisotropy of the artificial viscosity. Numerical examples are presented to show that even very simple problems, including basic problems in fluid dynamics, are not approximated well by schemes with anisotropic artificial viscosity, regardless of numerical parameters.

A DEFERRED-CORRECTION MULTIGRID ALGORITHM BASED ON A NEW SMOOTHER FOR THE NAVIER-STOKES EQUATIONS. Paolo Luchini, *University of Naples, Naples, ITALY.*

An algorithm which brings together the techniques of multigrid and deferred correction through their common relationship with imperfect Newton iteration manages to combine the ease of calculation of a low-order with the accuracy of a high-order difference approximation of any given differential-equation problem. A stable explicit Gauss-Seidel relaxation algorithm for the ψ-ζ Navier-Stokes equations based on an appropriate kind of "upwinding" of ψ- as well as ζ-derivatives, especially developed for use as a multigrid smoother in this context, is presented and the complete algorithm is tested on the standard conservative second-order discretization of the driven-cavity problem.

FLAIR: FLUX LINE-SEGMENT MODEL FOR ADVECTION AND INTERFACE RECONSTRUCTION. N. Ashgriz and J. Y. Poo, *State University of New York at Buffalo, Buffalo, New York, USA.*

A computational technique for solving fluid problems with free surfaces and interfaces is presented. The conventional cell volume fraction approach is employed for tracking the interfaces. However, for surface advection and its reconstruction, a new and more accurate FLAIR (flux line-segment model for advection and interface reconstruction) algorithm is developed. The surface is approximated by a set of line segments fitted at the boundary of every two neighboring computational cells. A criterion is

0021-9991/90 $3.00

developed for identifying the line-segment orientation by inspecting the cell volume fractions. The new cell volume fraction field is obtained by integrating the advected area underneath the interface line segment. As an example, this technique is applied to the capillary driven viscous flow of an initially elliptic, two-dimensional fluid zone. The problem is posed mathematically as a solution of the Navier–Stokes equations with moving free surface boundary conditions. The damping motion of the fluid zone is observed through transport of the free surface, which is related to the instantaneous internal velocity field under the influence of surface tension and viscous forces.

A TREATMENT OF DISCONTINUITIES IN SHOCK-CAPTURING FINITE DIFFERENCE METHODS. De-kang Mao, *University of California at Los Angeles, Los Angeles, California, USA.*

In this paper a treatment to sharpen discontinuities for shock capturing methods is introduced. The treatment is a modification of the underlying scheme that makes the computation on each side of the discontinuity use information only from that side. The modification is done by adding specific artificial terms to the underlying scheme. The correctness of the discontinuity's location is guaranteed by some limitation of the artificial terms. Shock tracking ideas are involved in the treatment; however, no lower dimensional grid is needed to fit the discontinuity. A high resolution technique is set up to find out the location of the discontinuity within the cell. Several numerical examples including spontaneous shocks, linear discontinuity calculations, and the blast waves problem are presented.

COMPUTER SIMULATIONS OF MULTIPLICATIVE STOCHASTIC DIFFERENTIAL EQUATIONS. P. D. Drummond and I. K. Mortimer, *The University of Queensland, St. Lucia, AUSTRALIA.*

A class of robust algorithms for the computer simulation of stochastic differential equations with multiplicative noise is investigated. Excellent agreement is obtained with the known analytic behaviour of the Kubo oscillator in the white noise limit. The algorithms include a known first-order one-dimensional explicit method, as well as implicit methods of increased stability. A distinction is drawn between classes of stochastic differential equations depending on the type of spatial variation or curvature defined by the diffusion tensor. This allows greatly simplified numerical implementations of the new algorithms in certain cases. The results of different techniques are compared for the case of the Kubo oscillator, where a semi-implicit technique gives the greatest accuracy.

MULTI-DOMAIN SIMULATIONS OF THE TIME-DEPENDENT NAVIER–STOKES EQUATIONS: BENCHMARK ERROR ANALYSIS OF SOME NESTING PROCEDURES. Terry L. Clark and William D. Hall, *National Center for Atmospheric Research, Boulder, Colorado, USA.*

This paper presents a benchmark error analysis of various approaches for treating multiple domain calculations within an anelastic finite difference model. One-way and two-way interactive nesting errors with and without temporal refinement are evaluated. The two-way interactive nesting approach is one where solutions between fine and coarse grid domains are matched through the simple post insertion of data. On the other hand, the equations can be matched by using the pressure defect correction approach. It is shown that, for the present model, the two-way interactive nesting method gives identical results to multi-domain solutions using the pressure defect correction approach. The present results indicate that in this type of anelastic framework, *a priori* matching of the equations is equivalent to the *a posteriori* matching of the solutions. This result is attributed to the inflexible nature of the Neumann boundary conditions on the fine mesh pressure which need to be specified from the coarse mesh. Since a large number of meteorological models employ the hydrostatic assumption, it is of interest to know of nesting errors attributable to this approximation. The results presented indicate essentially equivalent error levels for both the hydrostatic and non-hydrostatic systems of equations for the present case of airflow over an isolated mountain. It is shown how nesting technology can be used in a virtual sense to reduce the central memory requirements for large array sized numerical simulations. Nesting can be