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Abstracts of Papers to Appear in Future Issues

HIGH-RESOLUTION SHOCK-CAPTURING SCHEMES FOR INVISCID AND VISCOUS HYPERSONIC FLOWS. H. C. Yee, *NASA Ames Research Center, Moffett Field, California, USA*; G. H. Klopfer, *NEAR Incorporated, Mountain View, California, USA*; J.-L. Montagne, *ONERA, Chatillon, FRANCE.*

A class of high-resolution implicit total variation diminishing (TVD) type algorithms suitable for transonic and supersonic multidimensional Euler and Navier–Stokes equations has been extended to hypersonic computations. The improved conservative shock-capturing schemes are spatially second- and third-order and are fully implicit. They can be first- or second-order accurate in time and are suitable for either steady or unsteady calculations. Enhancement of stability and convergence rate for hypersonic flows is discussed. With the proper choice of the temporal discretization and implicit linearization, these schemes are fairly efficient and accurate for very complex two-dimensional hypersonic inviscid and viscous shock interactions. This study is complemented by a variety of steady and unsteady viscous and inviscid hypersonic blunt-body flow computations. Due to the inherent stiffness of viscous flow problems, numerical experiments indicated that the convergence rate is in general slower for viscous flows than for inviscid steady flows.

COUPLED FULLY IMPLICIT SOLUTION PROCEDURE FOR THE STEADY INCOMPRESSIBLE NAVIER–STOKES EQUATIONS. F. Sotiropoulos, *The Pennsylvania State University, State College, Pennsylvania, USA*; S. Abdallah, *University of Cincinnati, Cincinnati, Ohio, USA.*

This paper presents a new fully implicit procedure for the solution of the steady incompressible Navier–Stokes equations in primitive variables. The momentum equations are coupled with a Poisson-type equation for the pressure and solved using the Beam and Warming approximate factorization method. The present formulation does not require the iterative solution of the pressure equation at each time step. Thus, the major drawback of the pressure-Poisson approach, which made it prohibitively expensive for complex three-dimensional applications, is eliminated. Numerical solutions for the problem of the two-dimensional driven cavity are obtained using a non-staggered grid at Re = 100, 400, and 1000. All the computed results are obtained without any artificial dissipation. This feature of the present procedure demonstrates its excellent convergence and stability characteristics. Those characteristics result from the coupling of the pressure equation, which is elliptic in space, with the momentum equations.

NON-OSCILLATORY CENTRAL DIFFERENCING FOR HYPERBOLIC CONSERVATION LAWS. Haim Nessyahu and Eitan Tadmor, *Tel Aviv University, Tel Aviv, ISRAEL and NASA Langley Research Center, Hampton, Virginia, USA.*

Many of the recently developed high-resolution schemes for hyperbolic conservation laws are based on upwind differencing. The building block of these schemes is the averaging of an approximate Godunov solver; its time consuming part involves the field-by-field decomposition which is required in order to identify the "direction of the wind." Instead, we propose to use as a building block the more robust Lax–Friedrichs (LxF) solver. The main advantage is simplicity: no Riemann problems are solved and hence field-by-field decompositions are avoided. The main disadvantage is the excessive numerical viscosity typical to the LxF solver. We compensate for it by using high-resolution MUSCL-type interpolants. Numerical experiments show that the quality of the results obtained by such convenient central differencing is comparable with those of the upwind schemes.

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ON A DIRECT METHOD FOR SOLVING HELMHOLTZ' TYPE EQUATIONS IN 3D RECTANGULAR REGIONS.
Aristides Th. Marinos, *Athens, GREECE.*

A direct solution method for solving elliptic pde's of the type

$$k_x(z) \cdot \vartheta^2\varphi/\vartheta x^2 + k_y(z) \cdot \vartheta^2\varphi/\vartheta y^2 + k_z \cdot \vartheta^2\varphi/\vartheta z^2 + \sigma(z) \cdot \varphi = f(x, y, z)$$

in 3D parallelepipeds with $k_z = \text{const}$ and $k_x(z)$, $k_y(z)$, $\sigma(z)$ continuous functions of z, is presented. The spatial derivatives are approximated using the Hermite approach (Mehrstellenverfahren) with $O(h^6)$ truncation error for Dirichlet boundary conditions or for periodic solutions of the problem. For Neumann conditions, it seems that in order to retain the direct character of the numerical algorithm employed, one should approximate the first spatial derivatives on the boundary by means of conventional schemes having a truncation error of $O(h^3)$ type rather than $O(h^6)$ which accordingly reduce the overall accuracy of the results. Despite the substantial reduction of the overall accuracy for Neumann conditions, this case has not been excluded, because the structure of the difference equations remains invariant for problems in which, instead of known values of first-order normal derivatives at the boundaries, these very boundaries constitute symmetry planes of the solution. This feature allows a direct solution method to be used for such a problem, whereas the $O(h^6)$ truncation error of the difference schemes employed is retained. The given pde is discretised on a three-dimensional grid and the set of difference equations is formulated as a linear system of matrix equations whose solution is found by a suitable decomposition of unknowns based on knowledge of the eigenvalues and eigenvectors of simple tridiagonal matrices. A hint for extending the applicability of the method—by means of a coordinate transformation—in cylindrical domains with an annular cross section, is also given.

ABSORBING BOUNDARY CONDITIONS FOR SECOND-ORDER HYPERBOLIC EQUATIONS. Hong Jiang, *University of Alberta, Edmonton, CANADA*; Yau Shu Wong, *NASA Lewis Research Center, Cleveland, Ohio, USA.*

A uniform approach to construct absorbing artificial boundary conditions for second-order linear hyperbolic equations is proposed. The nonlocal boundary condition is given by a pseudodifferential operator that annihilates travelling waves. It is obtained through the dispersion relation of the differential equation by requiring that the initial-boundary value problem admits the wave solutions travelling in one direction only. Local approximation of this global boundary condition yields an nth-order differential operator. It is shown that the best approximations must be in the canonical forms which can be factorized into first-order operators. These boundary conditions are perfectly absorbing for wave packets propagating at certain group velocities. A hierarchy of absorbing boundary conditions is derived for transonic small perturbation equations of unsteady flows. These examples illustrate that the absorbing boundary conditions are easy to derive, and the effectiveness is demonstrated by the numerical experiments.

VISCOUS EFFECTS ON PROPAGATION AND REFLECTION OF SOLITARY WAVES IN SHALLOW CHANNELS.
C. J. Tang, V. C. Patel, and L. Landweber, *The University of Iowa, Iowa City, Iowa, USA.*

A numerical method for the solution of the Navier–Stokes equations for flows with a free surface, with emphasis on the exact kinematic and dynamic boundary conditions at the free surface, is described. The method is used to study the propagation of a solitary wave in a shallow channel, and the reflection of such a wave from a vertical wall. The numerical results are compared with analytical solutions which neglect or simplify the effects of viscosity and surface tension.

FLUX-SPLIT ALGORITHMS FOR FLOWS WITH NON-EQUILIBRIUM CHEMISTRY AND VIBRATIONAL RELAXATION. B. Grossman and P. Cinnella, *Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.*

The numerical computation of gas flows with non-equilibrium thermodynamics and chemistry is considered. Several thermodynamic models are considered, including an equilibrium model, a general non-equilibrium model and a simplified model based upon vibrational relaxation. Flux-splitting procedures are developed for the fully-coupled inviscid equations involving fluid dynamics, chemical production, and internal energy relaxation processes. New forms of flux-vector split and flux-difference split algorithms valid for non-equilibrium flow, are embodied in a fully coupled, implicit, large-block structure. Several numerical examples in one space dimension are presented, including high-temperature shock tube and nozzle flows.

NUT: A FAST 3-DIMENSIONAL NEUTRAL TRANSPORT CODE. P. M. Valanju, *The University of Texas, Austin, Texas, USA.*

We present a fast code for calculating the steady-state transport of neutral atoms in an axially symmetric background plasma. The primary source for the neutrals is not required to have any symmetry. Due to the small momentum transfer involved in charge exchange, the secondary neutral atoms emerge with the local velocity distribution of the plasma ions. Some neutrals are lost due to ionization. The neutral transport is described by an integral equation for the neutral source. With a careful choice of a three-dimensional spatial grid, the small scale features of these equations can be integrated analytically to yield a set of algebraic equations that can be solved by only a few iterations. This results in a fast and compact algorithm which can be used as a subroutine in plasma simulation codes. Comparisons with other currently used codes and with experimental measurements show good agreement.

NOTES TO APPEAR

TRIPIC: TRIANGULAR-MESH PARTICLE-IN-CELL CODE. Masami Matsumoto, *Yonago National College of Technology, Yonago, Tottori, JAPAN*; Shigeo Kawata, *Nagaoka University of Technology, Nagaoka, Niigata, JAPAN.*

AN ANALYTIC GREEN'S FUNCTIONS METHOD IN PSEUDO-SPECTRAL NAVIER–STOKES SOLVERS FOR BOUNDARY LAYER AND CHANNEL FLOWS. J. Andrzej Domaradzki, *University of Southern California, Los Angeles, California, USA.*

ON THE CALCULATION OF COMBINED CORRECTIONS IN THE LMTO METHOD. A. M. Bratkovsky, *I. V. Kurchatov Institute for Atomic Energy, Moscow, USSR*; S. Yu. Savrasov, *P. N. Lebedev Physical Institute, Moscow, USSR.*

THE DYNAMICAL INTERACTIONS OF COSMIC STRINGS. K. J. M. Moriarty, *Dalhousie University, Halifax, Nova Scotia, CANADA and John von Neumann National Computer Center, Princeton, New Jersey, USA*; Eric Meyers, *Dalhousie University, Halifax, Nova Scotia, CANADA and Boston University, Boston, Massachusetts, USA*; Claudio Rebbi, *Boston University, Boston, Massachusetts, USA.*

AN ALGORITHM FOR THE SOLUTION OF THE EIGENVALUE SCHRÖDINGER EQUATION. C. D. Papageorgiou, A. D. Raptis, and T. E. Simos, *National Technical University of Athens, Athens, GREECE.*

AN ALGORITHM FOR THE GENERATION OF RANDOM NUMBERS WITH DENSITY $c\exp(-\lambda|x|)$. N. Bralic, R. Espinosa, and C. Saavedra, *Universidad Catolica de Chile, Santiago, CHILE.*

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