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Abstracts of Papers to Appear

A CONSERVATIVE ADAPTIVE PROJECTION METHOD FOR THE VARIABLE DENSITY INCOMPRESSIBLE NAVIER–STOKES EQUATIONS. Ann S. Almgren, John B. Bell, Phillip Colella, Louis H. Howell, and Michael L. Welcome. *Lawrence Berkeley National Laboratory, Berkeley, California 94720.*

In this paper we present a method for solving the equations governing time-dependent, variable density incompressible flow in two or three dimensions on an adaptive hierarchy of grids. The method is based on a projection formulation in which we first solve advection–diffusion equations to predict intermediate velocities, and then project these velocities onto a space of approximately divergence-free vector fields. Our treatment of the first step uses a specialized second-order upwind method for differencing the nonlinear convection terms that provides a robust treatment of these terms suitable for inviscid and high Reynolds number flow. Density and other scalars are advected in such a way as to maintain conservation, if appropriate, and free-stream preservation. Our approach to adaptive refinement uses a nested hierarchy of logically rectangular grids with simultaneous refinement of the grids in both space and time. The integration algorithm on the grid hierarchy is a recursive procedure in which coarse grids are advanced in time, fine grids are advanced multiple steps to reach the same time as the coarse grids and the data at different levels are then synchronized. The single grid algorithm is described briefly, but the emphasis here is on the time-stepping procedure for the adaptive hierarchy. Numerical examples are presented to demonstrate the algorithms's accuracy and convergence properties and to illustrate the behavior of the method. An additional example demonstrates the performance of the method on a more realistic problem, namely, a three-dimensional variable density shear layer.

A TIME-DOMAIN METHOD FOR THE DETERMINATION OF UNSTEADY PRESSURE WITH A TUBE OF CONSTANT CROSS SECTION. K. Ehrendorfer, F. Ottitsch, and H. Sockel. *Institut für Strömungslehre und Wärmeübertragung, Technische Universität Wien, Wiedner Hauptstrasse 7, A-1040, Wien, Austria.* E-mail: kehren@hp.fluid.tuwien.ac.at.

In this paper a new method for the determination of unsteady pressure with a tubing system is shown. The conventional methods try either to optimize the frequency behaviour of the tubing system by implementing restrictors or instantaneous jumps in the cross-sectional area or to correct the measurement by using the transfer function of the tubing system. The new method presented here simply uses a tube with constant, circular cross section and solves the governing fluid-mechanic equations in the time-domain by numerically propagating in the direction of the spatial axis.

EFFICIENT AND HIGHLY ACCURATE COMPUTATION OF A CLASS OF RADIALLY SYMMETRIC SOLUTIONS OF THE NAVIER–STOKES EQUATION AND THE HEAT EQUATION IN TWO DIMENSIONS. Henrik O. Nordmark. *Department of Mathematics, Universidad Autonoma Metropolitana, Azcapotzalco, Mexico City, Mexico.* E-mail: nord@hp9000a1.uam.mx.

In this paper we test several different formulas for the computation of the exact vorticity and angular velocity in certain radially symmetric solutions of the two-dimensional Navier–Stokes equation in vorticity-stream function form. The class of initial conditions for the vorticity considered here has often been used by many authors in the study of vortex methods. However, only in the case of zero viscosity has it been possible to efficiently compute the exact vorticity and velocity at later times. The expressions for the vorticity and angular velocity, given in this paper,

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enable us to compute these quantities both efficiently and highly accurately or nonzero viscosity. This makes it feasible to obtain reliable error measurements in the study of vortex methods for the Navier–Stokes equation.

SECOND-ORDER UPWINDING THROUGH A CHARACTERISTIC TIME-STEP MATRIX FOR COMPRESSIBLE FLOW CALCULATIONS.

Ying Huang and Alain Lerat. *SINUMEF Laboratory, ENSAM, 151, Bd. de l'Hopital, 75013, Paris, France.* E-mail: huang@paris.ensam.fr and lerat@paris.ensam.fr.

An efficient multidimensional scheme is constructed for solving the compressible Euler equations. It is deduced from a centered scheme of the Lax–Wendroff type by using a special time-step in the numerical flux, namely a matricial characteristic time-step. This produces a compact second-order upwinding in a very simple way and leads to accurate nonoscillatory solutions without limiters, entropy correction, or other dissipative correction. The design principle is analysed for hyperbolic systems of conservation laws. It is shown to be close to and less dissipative than a genuinely multidimensional upwinding. Numerical applications are presented for subsonic, transonic, and supersonic aerodynamic problems.

ON THE ANALYSIS AND CONSTRUCTION OF PERFECTLY MATCHED LAYERS FOR THE LINEARIZED EULER EQUATIONS.

J. S. Hesthaven. *Division of Applied Mathematics, Brown University, Box F, Providence, Rhode Island 02912.* E-mail: jansh@cfm.brown.edu.

We present a detailed analysis of a recently proposed perfectly matched layer (PML) method for the absorption of acoustic waves. The split set of equations is shown to be only weakly well-posed and ill-posed under small low-order perturbations. This analysis provides the explanation for the stability problems associated with the spilt field formulation and illustrates why applying a filter has a stabilizing effect. Utilizing recent results obtained within the context of electromagnetics, we develop strongly well-posed absorbing layers for the linearized Euler equations. The schemes are shown to be perfectly absorbing independent of frequency and angle of incidence of the wave in the case of a nonconvecting mean flow. In the general case of a convecting mean flow, a number of techniques is combined to obtain absorbing layers exhibiting PML-like behavior. The efficacy of the absorbing layers is illustrated though the solution of aero-acoustic benchmark problems.