linear and nonlinear waves, after which first- and second-order partial differential equations are introduced as absorbing boundary conditions for the linearized model. Well-posedness is investigated and it is shown that the reflection properties of the second-order equation are superior to those of the first-order equation.

Absorbing Boundary Conditions for Free Surface Wave Simulations with a Panel Method. J. Broeze and J. E. Romate. *Delft Hydraulics, P.O. Box 152, 8300 AD Emmeloord, The Netherlands.*

The numerical implementation and stability of first- and second-order absorbing boundary conditions for simulating free surface gravity waves are considered. The free surface waves are solved with a panel method. The stability of the boundary conditions is proved, assuming certain properties of the integral operator. Arguments are given that support these assumptions. The theoretical results are confirmed in the test cases and the boundary conditions give low reflections for plane waves.

Upwind Relaxation Methods for the Navier–Stokes Equations Using Inner Iterations. Arthur C. Taylor III. *Old Dominion University, Norfolk, Virginia 23529-0247, USA*; Wing-Fai Ng and Robert W. Walters. *Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0238, USA.*

An upwind line relaxation algorithm for the Navier–Stokes equations which employs inner iterations is applied to a supersonic and a subsonic test problem. The purpose of using inner iterations is to accelerate the convergence to steady-state solutions, thereby reducing the overall CPU time. A convergence criterion is developed to assist in automating the inner iterative procedure. The ability of the line inner iterative procedure to mimic the quadratic convergence of the direct solver method is confirmed in both test problems, but some of the non-quadratic inner iterative results were more efficient than the quadratic results. In the supersonic test case, the use of inner iterations was very efficient in reducing the residual to machine zero. For this test problem, the inner iteration method required only about 65% of the CPU time which was required by the most efficient line relaxation method without inner iterations. In the subsonic test case, poor matrix conditioning forced the use of under-relaxation in order to obtain convergence of the inner iterations, resulting in an overall method which was less efficient than line relaxation methods which employ a more conventional CPU savings strategy.

An Improved Upwind Finite Volume Relaxation Method for High Speed Viscous Flows. Arthur C. Taylor III. *Old Dominion University, Norfolk, Virginia 23529-0247, USA*; Wing Fai Ng and Robert W. Walters. *Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0238, USA.*

An improved upwind relaxation algorithm for the Navier–Stokes equations is presented, and results are given from the application of the method to two test problems, including (1) a shock/boundary layer interaction on a flat plate ($M_\infty = 2.0$) and (2) a high-speed inlet ($M_\infty = 5.0$). The technique is restricted to high-speed (i.e., supersonic/hypersonic) viscous flows. The new algorithm depends on a partitioning of the global domain into regions or sub-domains, where a relatively thin "elliptic" region is identified near each solid wall boundary, and the remainder of the flowfield is identified to be a single larger "hyperbolic" (i.e., hyperbolic/parabolic in the streamwise direction) region. A direct solution procedure by lower/upper factorization is applied to the elliptic region(s), the results of which are then coupled to a standard line Gauss–Seidel relaxation sweep across the entire domain in the primary flow direction. In the first test problem, the new algorithm reduced total run times as much as 75% when compared to the standard alternating forward/backward vertical line Gauss–Seidel (VLGS) algorithm, whereas in the second test problem, a total savings as high as 20% was achieved. Essentially all of this improvement occurred only after the initial transient in the solution was overcome. However, in the second test problem, a significant improvement in the computational performance of the standard forward/backward VLGS algorithm was noted when overcoming the initial transient simply by converting from the use of conserved variables to primitive variables in the spatial discretization and linearization of all terms.

An Anti-Spatial-Aliasing Filter for Explicit Modeling and Imaging in Inhomogeneous Media. Alvin K. Benson. *Brigham Young University, Provo, Utah 84602, USA.*

An explicit finite difference solution to the scalar wave equation in isotropic, inhomogeneous media is completed by filtering out nonphysical contributions to the data. This digital, anti-spatial-aliasing filter and some associated limits on angular frequency are determined. The filter is a projection operator determined from a constrained least-squares fit and can be implemented in the computer algorithm at either of two places. Furthermor, the filter should be applicable to *any* explicit finite difference solution to the wave equation. Unlike a standard dip filter, this filter is computationally flexible, efficient, and necessary in inhomogeneous media with rapid lateral and vertical velocity changes.

Numerical Solution of the Steady Stokes Equations. Eric Yu Tau. *Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720, USA.*

In this paper we present a fast numerical technique for finding solutions of the steady-state Stokes equations on both two- and three-dimensional domains. We implement the method on a special staggered grid for a rectangular (cubic) domain and obtain a solution in an order of $O(N \log N)$ operations for both two- and three-dimensional cases, where N is the number of grid points in the domain. The main idea is to derive from the Stokes equations an equation for the pressure p, $Ap = b$, where the matrix A is semi-positive definite and very-well conditioned on the orthogonal complement of its null space.

Box-Counting Algorithm and Dimensional Analysis of a Pulsar. F. H. Ling and G. Schmidt. *Stevens Institute of Technology, Hoboken, New Jersey 07030, USA.*

It is argued that the use of the box-counting algorithm to calculate the correlation dimension is a better choice than the Grassberger–Procaccia (correlation integral) algorithm for dealing with an experimental data set. This is illuminated by treating three classical examples: the logistic map, the Hénon map and the Lorenz equation. The intensity data of a pulsar is also treated which is revealed to have a least embedding dimension of 14 and the correlation dimension of about 4.5.

The Inclusion of Collisional Effects in the Splitting Scheme. L. Demeio. *Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.*

An algorithm is given for the numerical solution of the Boltzmann equation for a one-dimensional unmagnetized plasma with immobile ions, in which collisional effects are described by the Bhatnagar–Gross–Krook (BGK) model. The algorithm is a straightforward generalization of the splitting scheme, which solves the one-dimensional Vlasov–Poisson system. The accuracy of the splitting scheme to second order in Δt is preserved.