absorbing Rayleigh waves, which propagate along free surfaces of elastic media. The boundary formulas developed here can be applied without modification to problems in both two and three dimensions.

A COMPARATIVE STUDY OF ADVANCED SHOCK-CAPTURING SCHEMES APPLIED TO BURGERS' EQUATION. H. Q. Yang and A. J. Przekwas. *CFD Research Corporation, 3325-D Triana Boulevard, Huntsville, Alabama 35805, USA.*

In recent years, a number of new shock-capturing finite difference schemes, often called high resolution schemes, have been proposed. We have considered several variations of the TVD and FCT schemes and geometrical approaches such as MUSCL, ENO, and PPM. Included is an organized overview and classification of the schemes. Only essential features are described, and numerical implementation is discussed. Much of the mathematical theory is omitted, but a key source reference list is provided. In this paper we present a comparative study of these schemes applied to the Burgers' equation. The objective is to assess their performance for problems involving formation and propagation of shocks, shock collisions, and expansion of discontinuities.

ABSORBING BOUNDARY CONDITIONS, DIFFERENCE OPERATORS, AND STABILITY. R. A. Renaut. *Arizona State University, Tempe, Arizona 85287-1804, USA.*

In this paper we present a review of some of the methods currently used for solving the absorbing boundary problem for the two-dimensional scalar wave equation. We show the relationship between the methods of Lindman and Clayton and Engquist. Through this relationship we can derive discretizations of any rational approximation to the one-way wave equation. We prove that, for all the cases considered here, which can be solved in a manner similar to Lindman's approach, the bounds imposed on the Courant number for stability at the boundary are no more severe than the bound $1/\sqrt{2}$ required for stability of the interior scheme. These bounds are, however, necessary but not sufficient. We also compare the methods reviewed numerically. It is demonstrated that Lindman's scheme is no better than a sixth-order approximation of Halpern and Trefethen. For low-order approximations, Higdon's one-dimensional equations are satisfactory, but as the order increases the two-dimensional form of the equations, as derived by Halpern and Trefethen, is preferable.

A COMBINED SPECTRAL-FINITE ELEMENT METHOD FOR SOLVING TWO-DIMENSIONAL UNSTEADY NAVIER–STOKES EQUATIONS. Ben-yu Guo and Wei-ming Cao. *Shanghai University of Science and Technology, Shanghai, China.*

In this paper, a combined Fourier spectral-finite element method is proposed for solving two-dimensional, semi-periodic, unsteady Navier–Stokes equations. The convergence is proved and the numerical results are presented.

A FINITE DIFFERENCE PROCEDURE FOR A CLASS OF FREE BOUNDARY PROBLEMS. Bengt Fornberg. *Corporate Research, Exxon Research and Engineering Company, Annandale, New Jersey 08801, USA*; and Rita Meyer-Spasche. *Max-Planck-Institute for Plasma Physics, IPP-EURATOM Association, D-W-8046 Garching, Germany.*

Finite difference schemes loose accuracy when free boundaries cross over rectangular grids. For a class of second-order equations, the leading error term at such a boundary can be eliminated by a simple correction strategy. This procedure works in any number of space dimensions and offers an alternative to (more costly and complicated) adaptive grid techniques.

ORTHOGONAL GRID GENERATION IN A 2D DOMAIN VIA THE BOUNDARY INTEGRAL TECHNIQUE. I. S. Kang. *Chemical Engineering Department, POSTECH, P.O. Box 125, Pohang, 790 Korea*; L. G. Leal. *Department of Chemical and Nuclear Engineering, University of California, Santa Barbara, Santa Barbara, California 93106, USA.*

A new numerical scheme is proposed for the generation of an orthogonal coordinate grid in an arbitrary simply connected two-dimensional domain. The scheme is robust and noniterative and is based on the conjunction of the familiar boundary integral technique with the covariant Laplace equation method for mapping. In the proposed scheme, two types of problems are considered: (1) Boundary correspondence is specified on two adjacent sides of the boundary, or (2) The distortion factor is specified in the product form $f(\xi, \eta) = \Pi(\xi)\,\Theta(\eta)$.

GLOBAL AND LOCAL REMESHING ALGORITHMS FOR COMPRESSIBLE FLOWS. C. J. Hwang and S. J. Wu. *Institute of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan, Republic of China.*

A new adaptive remeshing approach for unstructured meshes, which includes the error indicator, global, and local mesh regeneration techniques, has been developed in this paper. In this approach, nodes are first distributed according to the remeshing parameters, and those nodes are connected into a complete mesh. The concepts of side-based and vertex-based fronts are introduced to achieve the triangulation. According to the CPU time and the versatility, the vertex-based triangulation technique is proved to be more efficient. By using vertex-based triangulation approach, a local remeshing method, which regenerates only some regions of the flow domain, is presented. To demonstrate the reliability and availability of the proposed procedure, several compressible flow problems are investigated. The regular/stretched triangles and the mixed type of triangular and quadrilateral stretched elements are used. In this work, the Euler equations are solved by the multistep Runge–Kutta Galerkin finite element methods. From the numerical results, the approaches, which employ the directionally stretched elements, are effective and suitable for treating the flow problems with one-dimensional features. The development of the local remeshing algorithm for unsteady flows is worthwhile and important.

SPECTRAL METHODS IN TIME FOR A CLASS OF PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS. Glenn Ierley, Brian Spencer, and Rodney Worthing. *Department of Mathematical Sciences, Michigan Technological University, Houghton, Michigan 49931, USA.*

In this paper, we introduce a fully spectral solution for the partial differential equation $u_t + uu_x + vu_{xx} + \mu u_{xxx} + \lambda u_{xxxx} = 0$. For periodic boundary conditions in space, the use of a Fourier expansion in x admits of a particularly efficient algorithm with respect to expansion of the time dependence in a Chebyshev series. Boundary conditions other than periodic may still be treated with reasonable, though lesser, efficiency. For all cases, very high accuracy is attainable at moderate computational cost relative to the expense of variable order finite difference methods in time.

TIME DOMAIN NUMERICAL CALCULATIONS OF UNSTEADY VORTICAL FLOWS ABOUT A FLAT PLATE AIRFOIL. S. I. Hariharan and Yu Ping. *Department of Mathematical Sciences, University of Akron, Akron, Ohio 44325 USA*; J. R. Scott. *NASA Lewis Research Center, Cleveland, Ohio 44135, USA.*

A time domain numerical scheme is developed to solve for the unsteady flow about a flat plate airfoil due to imposed upstream, small amplitude, transverse velocity perturbations. The governing equation for the resulting unsteady potential is a homogeneous, constant coefficient, convective wave equation. Accurate solution of the problem requires the development of approximate boundary conditions which correctly model the physics of the unsteady flow in the far field. An accurate far field boundary condition is developed, and numerical results are presented using this condition. The stability of the scheme is discussed, and the stability restriction for the scheme is established as a function of the Mach number. Finally, comparisons are made with the frequency domain calculations by Scott and Atassi, and the relative strengths and weaknesses of each approach are assessed.

NUMERICAL ALGORITHMS FOR STRONG DISCONTINUITIES IN ELASTIC–PLASTIC SOLIDS. John A. Trangenstein and Richard B. Pember. *Computing and Mathematics Research Division, Lawrence Livermore National Laboratory L-316, P.O. Box 808, Livermore, California 94550, USA.*

In this paper the implementation of second-order Godunov methods for dynamic wave propagation in one-dimensional elastic–plastic solids is investigated. First, the Lagrangian form of the algorithm is reviewed, and then the algorithm is extended to the Eulerian frame of reference. This extension requires additional evolution equations to handle the history of the material along particle paths. Both the Lagrangian and Eulerian versions of the algorithm require appropriately accurate approximations to the solution of Riemann problems, in order to represent the interaction of waves at cell boundaries. Two inexpensive approximations to the solution of the Riemann problem are constructed, and the resulting algorithms are tested against the analytic solution of the Riemann problem for longitudinal motion in an elastic–plastic bar. These approximations to the Riemann problem are shown to work well, even for strong discontinuities. Finally, the numerical experience gained from the simple longitudinal bar problem is used to design an algorithm for strong shocks predicted by a realistic soil model.

A CLASS OF MONOTONE INTERPOLATION SCHEMES. Piotr K. Smolarkiewicz and Georg A. Grell. *National Center for Atmospheric Research, Boulder, Colorado 80307, USA.*

This paper discusses a class of monotone (nonoscillatory) interpolation schemes convenient for applications with a variety of problems arising in computational fluid dynamics. These interpolators derive from the flux-corrected-transport finite difference advection schemes. It is shown that any known dissipative advection algorithm may be implemented as an interpolation scheme. The resulting interpolation procedure retains the formal accuracy of the advection scheme and offers such attractive computational properties as preservation of a sign or monotonicity of the interpolated variable. The derived class of interpolators consists of schemes of different levels of accuracy, efficiency, and complexity, reflecting a rich variety of available advection schemes. Theoretical considerations are illustrated with idealized examples and selected applications to atmospheric fluid dynamics problems.

ON THE SUPPRESSION OF NUMERICAL OSCILLATIONS USING A NON-LINEAR FILTER. W. Shyy, M.-H. Chen, R. Mittal, and H. S. Udaykumar. *Department of Aerospace Engineering, Mechanics and Engineering Science, University of Florida, Gainesville, Florida 32611, USA.*

The idea of using a non-linear filtering algorithm to eliminate numerically generated oscillations is investigated. A detailed study is conducted to follow the development of numerical oscillations and their interaction with the filter. A relaxation procedure is also proposed to enhance the effectiveness of the filter. Three model problems, a 2D steady state scalar convection-diffusion equation, a 1D unsteady gas dynamics flow with shock and a 1D linear wave equation, have been designed to test the performance of the filtering algorithm. The effectiveness of the filter is assessed for convection schemes of different dispersive and diffusive characteristics, demonstrating that it is effective in eliminating oscillations with short wavelength, but oscillations of longer wavelengths are virtually unaffected. It is concluded that a proper combination of non-linear filter and dispersive numerical scheme is a viable alternative to dissipative schemes in resolving flows with sharp gradients and discontinuities.

PROJECTION METHODS COUPLED TO LEVEL SET INTERFACE TECHNIQUES. Jingyi Zhu and James Sethian. *Lawrence Berkeley Laboratory and Department of Mathematics, University of California, Berkeley, California 94720, USA.*

In this work, we consider the hydrodynamic problems with cold flame propagation by merging a second-order projection method for viscous Navier–Stokes equations with modern techniques for computing the motion of interfaces propagating with curvature-dependent speeds. This is part of the efforts in trying to approximate the solution of a simplified model of turbulent combustion. Results are given for a simple model of a flame burning in driven cavities and shear layers.

ADAPTIVE SPECTRAL METHODS WITH APPLICATION TO MIXING LAYER COMPUTATIONS. H. Guillard. *INRIA, Centre de Sophia-Antipolis, 2004 Av. des lucioles, 06565 Valbonne, France*; J. M. Male and R. Peyret. *Laboratoire de Mathématiques, CNRS UA-168, Université de Nice, Parc Valrose, 06034 Nice, France and INRIA, Centre de Sophia-Antipolis, 2004 Av de lucioles, 06565 Valbonne, France.*

This paper reports some experiments on the use of adaptive Chebyshev pseudospectral methods for compressible mixing layer computations. Different functionals measuring the optimality of the polynomial approximation are discussed and compared. In particular, we address the problem of the practical computation of the various functionals. The utility of the self-adaptive method is then demonstrated by some examples from compressible mixing layer calculations.