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Abstracts of Papers to Appear in Future Issues

LYAPUNOV EXPONENTS AND LOCALIZATION IN RANDOMLY LAYERED MEDIA. John A. Scales and Erik S. Van Vleck. *Department of Geophysics and Center for Wave Phenomena and Department of Mathematical and Computer Sciences, Colorado School of Mines, Golden, Colorado 80401.*

A variety of problems involving disordered systems can be formulated mathematically in terms of products of random transfer matrices, including Ising spin systems, optical and continuum mechanical wave propagation, and lattice dynamical systems. The growth or decay of solutions to these problems is governed by the Lyapunov spectrum of the product of these matrices. For continuum mechanical or optical wave propagation, the transfer matrices arise from the application of boundary conditions at the discontinuities of the medium. Similar matrices arise in lattice-based systems when the equations of motion are solved recursively. For the disordered lattice mechanical system, on which we focus in this paper, the scattering effects of the heterogeneities on a propagating pulse can be characterized by the frequency-dependent localization length—effectively the "skin depth" for multiple-scattering attenuation. Thus there is a close connection in these transfer matrix-based systems between localization and the Lyapunov spectrum. For the one-dimensional lattice, the matrices are 2×2 and, assuming certain models of disorder, both Lyapunov exponents are nonzero and sum to zero. Thus all propagating solutions are either exponentially growing or decaying. For higher dimensions the situation is more complicated since there is then a spectrum of exponents, making the calculations more difficult, and it is less clear just how to relate the Lyapunov exponents to a single localization length. Further, unlike for the Schrödinger equation, the transfer matrices associated with the lattice mechanical system are not symplectic. We describe a robust numerical procedure for estimating the Lyapunov spectrum of products of random matrices and show application of the method to the propagation of waves on a lattice. In addition, we show how to estimate the uncertainties of these exponents.

DEVELOPING NUMERICAL FLUXES WITH NEW SONIC FIX FOR MHD EQUATIONS. Necdet Aslan and Terry Kammash. *Fen-Ed. Physics Department, Marmara University, 81040 Göztepe Istanbul, Turkey; and Nuclear Engineering Department, University of Michigan, Ann Arbor, Michigan 48109.*

In this paper, the solution of a generalized system of hyperbolic equations by means of upwind, limited, second-order accurate fluxes including a new sonic fix is presented. The new sonic fix introduced here utilizes a dissipation term embedded directly in the fluxes and it is totally based on physical grounds producing the correct decay rate of sonic gradients. In addition to the sonic fix, the effects of the source term on the flux limiters are also introduced. The resulting scheme is applied to a variety of test problems resulting from the solutions of Euler's and magnetohydrodynamic (MHD) equations. To eliminate the divergence problem, a new implementation of a recently introduced scheme for the MHD equations which includes a divergence wave and a source related to $\nabla \cdot \mathbf{B}$ is introduced. The numerical test results obtained with this new scheme are in excellent agreement with previous results and they show that the scheme presented here is robust, accurate, and entropy satisfying by producing very sharp contact discontinuities and shocks without postshock oscillations and divergence errors.

A PARALLEL THREE-DIMENSIONAL COMPUTATIONAL AEROACOUSTICS METHOD USING NONLINEAR DISTURBANCE EQUATIONS. Philip J. Morris, Lyle N. Long, Ashok Bangalore, and Qunzhen Wang. *Department of Aerospace Engineering, The Pennsylvania State University, University Park, Pennsylvania 16802.*

This paper describes the application of a three-dimensional computational aeroacoustics (CAA) methodology to the prediction of jet noise. The technique has been implemented using parallel computers. In this approach the nonlinear disturbance equations are solved in a conservative form using a finite-difference based technique. A fourth-order optimized dispersion relation preserving scheme is used for spatial discretization and a fourth-order classical Runge–Kutta scheme is employed for temporal discretization. The three-dimensional CAA code has been parallelized using a domain decomposition strategy in the streamwise direction. The calculations are carried out on both IBM-SP2 and SGI Power-Challenge parallel computers using message passing interface routines to facilitate exchange of boundary data between adjacent nodes (processors). Excellent parallel performance has been obtained using the present code. Acoustic results are presented for a perfectly expanded supersonic axisymmetric jet under harmonic and random inlet conditions. Results are given for both the instantaneous and averaged flow and acoustic variables. Comparisons are made between the predictions and experimental data.

EIGENEQUATIONS AND COMPACT ALGORITHMS FOR BULK AND LAYERED ANISOTROPIC OPTICAL MEDIA: REFLECTION AND REFRACTION AT A CRYSTAL–CRYSTAL INTERFACE. J. J. Hodgkinson, S. Kassam, and Q. H. Wu. *Department of Physics, University of Otago, Dunedin, New Zealand.*

Eigenequations leading to compact algorithms for computing the optical properties of anisotropic media that may be stratified in the x-direction are described. For each medium a 4×4 matrix $\hat{F}$ of basis field vectors is determined as the eigenvectors of a 4×4 matrix form of Fresnel's equation. A minimum sort of the columns of $\hat{F}$ that is necessary for a birefringent cover or substrate separates basis vectors that carry power in the positive and negative x-directions, respectively. A sorting procedure is discussed for the most complicated refractive index section in which the outer and inner sheets do not touch and the outer sheet has a well-defined cusp. MATLAB code is provided for the implementation of basic routines.

WAVENUMBER-EXTENDED HIGH-ORDER UPWIND-BIASED FINITE-DIFFERENCE SCHEMES FOR CONVECTIVE SCALAR TRANSPORT. Yuguo Li. *CSIRO Division of Building, Construction and Engineering, Highett, Victoria 3190, Australia.*

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This paper proposes some new wavenumber-extended high-order upwind-biased schemes. The dispersion and dissipation errors of upwind-biased finite-difference schemes are assessed and compared by means of a Fourier analysis of the difference schemes. Up to 11th-order upwind-biased schemes are analyzed. It is shown that both the upwind-biased scheme of order $2N - 1$ and the corresponding centered differencing scheme of order $2N$ have the same dispersion characteristics; thus, the former can be considered to be the latter plus a correction that reduces the numerical dissipation. The new second-order wavenumber-extended scheme is tested and compared with some well-known schemes. The range of wavenumbers that are accurately treated by the upwind-biased schemes is improved by using additional constraints from the Fourier analysis to construct the new schemes. The anisotropic behavior of the dispersion and dissipation errors is also analyzed for both the conventional and the new wavenumber-extended upwind-biased finite-difference schemes.