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Abstracts of Papers to Appear in Future Issues

THE EFFECT OF FILTERING ON THE PSEUDOSPECTRAL SOLUTION OF EVOLUTIONARY PARTIAL DIFFERENTIAL EQUATIONS. L. S. Mulholland and D. M. Sloan, *University of Strathclyde, SCOTLAND.*

This paper examines the effect of filtering on the solution of time-dependent partial differential equations by the pseudospectral method. It is shown that if spatial discretisation is effected using the Fourier pseudospectral method the computed solution will be an approximation to the solution of a modified differential equation. The changes in dispersive and dissipative properties induced by the modification are examined, and numerical results are presented which illustrate these changes for both linear and nonlinear equations. Numerical results are also presented which show the effect of filtering on Chebyshev pseudospectral solutions of time-dependent equations.

VECTORIZATION OF A MONTE CARLO SIMULATION SCHEME FOR NONEQUILIBRIUM GAS DYNAMICS. Iain D. Boyd, *NASA Ames Research Center, California, USA.*

The numerical performance of a Monte Carlo scheme used in the analysis of nonequilibrium gas dynamics has been greatly improved. This improvement is attained by careful implementation of the algorithm in order to take advantage of the vector hardware of supercomputers. The performance of the modified implementation is demonstrated by application to three different flow problems. First, the one-dimensional standing shock wave is considered. Due to the relative simplicity of this example, it is shown that an adequate solution is obtained in a very small computational time. The second problem considered is the flow of an expanding gas through an axisymmetric nozzle. Lastly, the hypersonic flow of argon over a three-dimensional wedge is computed. This problem illustrates the increase in the number of molecules which may be employed in the simulation due to the improved performance of the algorithm. In fact, over 10 million particles are employed, which is the largest number reported in the literature for the simulation scheme considered.

THREE-DIMENSIONAL VORTEX SIMULATION OF ROLLUP AND ENTRAINMENT IN A SHEAR LAYER. Omar M. Knio and Ahmed F. Ghoniem, *Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.*

The transport element method is extended to three dimensions to study the evolution of scalar fields in a flow with high vorticity concentration. The numerical scheme is based on following Lagrangian computational elements employed in the transport of vorticity and local scalar gradients. The formulation of the numerical scheme is first presented as a direct generalization of the three-dimensional vortex element method. The numerical algorithms required to implement this scheme are then developed. Problems associated with severe distortion of the flow map due to the growth of perturbations are shown to cause difficulties including loss of numerical accuracy and resolution. Means to overcome this problem are discussed and are shown to yield accurate solutions. Two grid-based and two grid-free methods for the computation of vorticity stretching are implemented. The accuracy of the methods is discussed in the light of numerical results which reveal the need for a careful treatment of the discrete form of the vorticity transport equation. The methods are applied to study the evolution of an initially two-dimensional shear layer, perturbed in the streamwise and spanwise directions. Attention is focused

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on the role of the spanwise instability in enhancing the rate of scalar entrainment into the large-scale structures which form as the streamwise instability develops. Two mechanisms, associated with the onset of three-dimensional instability, are responsible for this enhancement: vorticity intensification within the large eddy core due to spanwise stretching which delays its collapse, and generation of transverse entrainment currents towards the eddy core due to the formation of streamwise vortex structures within the core and along the braids between neighboring cores. Preferential entrainment is detected along the spanwise direction due to the streamwise vorticity.

EXACT ANALYSIS OF NONLINEAR INSTABILITY IN A DISCRETE BURGERS' EQUATION. M. F. Maritz and S. W. Schoombie, *University of the Orange Free State, SOUTH AFRICA.*

A family of explicit nonlinear numerical schemes for Burgers' equation are derived by means of a discrete version of the Hopf–Cole transformation. Exact nonlinear stability conditions for these schemes are then found, and for one particular scheme the exact stability criteria are compared to the conventional linearized stability condition.

A NUMERICAL TECHNIQUE FOR TWO-DIMENSIONAL GRID GENERATION WITH GRID CONTROL AT ALL OF THE BOUNDARIES. K. Hsu and S. L. Lee, *National Tsing-Hua University, Taiwan, REPUBLIC OF CHINA.*

A numerical technique is developed in the present investigation to generate grids by the use of the Poisson equations. Orthogonal grids are obtained along all of the boundaries with desired grid size specified at the two boundaries $\eta = 0$ and $\eta = \eta_{\max}$. The "stand-off" grid spacing between $\xi = 0$ and $\xi = \Delta\xi$ and between $\xi = \xi_{\max} - \Delta\xi$ and $\xi = \xi_{\max}$ can be controlled by employing a proper grid point distribution on the boundaries $\eta = 0$ and $\eta = \eta_{\max}$. Thanks to the orthogonal boundary grids, the present numerical technique is applicable to complex geometry by patching grids without slope discontinuity across the interface of the patches. This technique also allows the Poisson equations to generate coordinates for *O*-type grid system and for periodic turbine cascades. In the course of grid generation, the magnitudes of the required control functions might be very large in a region where clustering grids are needed. To guarantee a good numerical stability in spite of the values of the control functions, the weighting function scheme along with the SIS solver is employed. Through the examples illustrated in the present study, the negative Jacobian reported by previous investigators is shown not to arise from the use of the Poisson equations. It, indeed, comes from the truncation error of the central difference scheme used by them.

THE APPLICATION OF THE PRECONDITIONED BICONJUGATE GRADIENT ALGORITHM TO NLTE RATE MATRIX EQUATIONS. Sumanth Kaushik and Peter L. Hagelstein, *Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.*

This paper reports the success of the preconditioned biconjugate gradient (PBCG) and the conjugate gradient square (CGS) algorithm in solving the matrix equations resulting from the discretization of systems of population rate equations which arise in nonequilibrium kinetics modeling. The success of the PBCG and CGS can be attributed to two main ideas: First, the singularity of the rate matrix resulting from population conservation requirement was removed through a reduction of matrix order so as to improve the condition number of the matrix. Second, an efficient preconditioner was found to reduce the eigenvalue spread of the rate matrix. The preconditioning matrix was selected on the basis of retaining the largest few rates in each column of the well conditioned rate matrix. This preconditioner, along with the reduced rate matrix, enabled the algorithms to converge very rapidly so as to make it an attractive alternative to standard direct methods.