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Abstracts of Papers to Appear in Future Issues

A HIGH-RESOLUTION HYBRID COMPACT-ENO SCHEME FOR SHOCK-TURBULENCE INTERACTION PROBLEMS. N. A. Adams and K. Shariff. *Center for Turbulence Research, NASA Ames Research Center, MS 202 A-1, Moffett Field, California, 94035–1000.*

A class of upwind-biased finite-difference schemes with a compact stencil is proposed in general form, suitable for the time-accurate direct numerical simulation of fluid-convection problems. These schemes give uniformly high approximation order and allow for a spectral-like wave resolution while dissipating non-resolved wavenumbers. When coupled with an essentially non-oscillatory scheme near discontinuities, the compact schemes become shock-capturing and their resolution properties are preserved. The derivation of the compact schemes is discussed in detail. Their convergence and resolution properties as well as numerical stability are analyzed. Upwinding and coupling procedures are described. Application examples for typical non-linear wave interaction problems are given.

A METHOD FOR DETERMINING THE VELOCITY INDUCED BY HIGHLY ANISOTROPIC VORTICITY BLOBS. J. S. Marshall* and J. R. Grant.† **Department of Mechanical Engineering and Iowa Institute of Hydraulic Research, The University of Iowa, Iowa City, Iowa 52242; and †Naval Undersea Warfare Center, Newport, Rhode Island 02841.*

Resolution of boundary layer flows at moderate or high Reynolds numbers with the vortex blob method requires a great many isotropic elements. In this paper, an approximate method for determination of the induced velocity from highly anisotropic vorticity blobs is presented, and issues related to use of anisotropic elements in calculations with vortex blob algorithms for high Reynolds number near-wall flows are examined. The method presented here can be used to determine the induced velocity from smooth blob functions of arbitrary form, provided that the vorticity length scale associated with the blob is much less in one direction than in orthogonal directions. The ratio of these length scales is called the blob aspect ratio, ε, and is used as a small parameter to construct an asymptotic approximation to the induced velocity field. This method is applied in the present paper to derive induced velocity expressions for anisotropic Gaussian blob functions in both two and three dimensions. It is argued, using test calculations for a Blasius boundary layer, that although direct calculation of the induced velocity requires about an order of magnitude more CPU time for anisotropic Gaussian elements than for isotropic elements, this difference is more than made up for by a reduction of several orders of magnitude in the number of elements needed to resolve boundary layer flows at moderate to high Reynolds numbers. It is also found that the standard vortex blob representation leads to errors in the calculation of wall slip velocity and wall shear stress due to smoothing of the discontinuity between the real and image vorticity fields at the wall, but that these errors can be avoided by placing doublet-type elements along the wall.

ON THE NUMERICAL SOLUTION OF THE SINE–GORDON EQUATION. I. INTEGRABLE DISCRETIZATIONS AND HOMOCLINIC MANIFOLDS. M. J. Ablowitz,* B. M. Herbst,*,† and Constance Schober.* **Program in Applied Mathematics, University of Colorado, Boulder, Colorado; and †Department of Applied Mathematics, The University of the Orange Free State, Bloemfontein 9300, South Africa.*

In this, the first of two papers on the numerical solution of the sine–Gordon equation, we investigate the numerical behavior of a double discrete, completely integrable discretization of the sine–Gordon equation. For certain initial values, in the vicinity of homoclinic manifolds, this discretization admits an instability in the form of grid scale oscillations. We clarify the nature of the instability through an analytical investigation supported by numerical experiments. In particular, a perturbation analysis of the associated linear spectral problem shows that the initial values used for the numerical experiments lie exponentially close to a homoclinic manifold. This paves the way for the second paper, where we use the nonlinear spectrum as a basis for comparing different numerical schemes.

SCALAR AND PARALLEL OPTIMIZED IMPLEMENTATION OF THE DIRECT SIMULATION MONTE CARLO METHOD. Stefan Dietrich and Iain D. Boyd. *Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca, New York 14853.*

This paper describes a new concept for the implementation of the direct simulation Monte Carlo (DSMC) method. It uses a localized data structure based on a computational cell to achieve high performance, especially on workstation processors, which can also be used in parallel. Since the data structure makes it possible to freely assign any cell to any processor, a domain decomposition can be found with equal calculation load on each processor while maintaining minimal communication among the nodes. Further, the new implementation strictly separates physical modeling, geometrical issues, and organizational tasks to achieve high maintainability and to simplify future enhancements. Three example flow configurations are calculated with the new implementation to demonstrate its generality and performance. They include a flow through a diverging channel using an adapted unstructured triangulated grid, a flow around a planetary probe, and an internal flow in a contractor used in plasma physics. The results are validated either by comparison with results obtained from other simulations or by comparison with experimental data. High performance on an IBM SP2 system is achieved if problem size and number of parallel processors are adapted accordingly. On 400 nodes, DSMC calculations with more than 100 million particles are possible.

NUMERICAL STUDY FOR THE THREE-DIMENSIONAL RAYLEIGH–TAYLOR INSTABILITY THROUGH THE TVD/AC SCHEME AND PARALLEL COMPUTATION. X. L. Li,* B. X. Jin,† and J. Glimm.‡ *Department of Mathematical Science, Indiana University-Purdue University at Indianapolis, Indianapolis, Indiana 46202; †Computing Center, Academia Sinica, China; and ‡Department of Applied Mathematics and Statistics, University at Stony Brook, Stony Brook, New York 11794.*

The Rayleigh–Taylor instability is a gravity driven instability of a

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contact surface between fluids of different densities. The growth of this instability is sensitive to numerical or physical mass diffusion. For this reason, high resolution of the contact discontinuity is particularly important. In this paper, we address this problem using a second-order TVD finite difference scheme with artificial compression. We describe our numerical simulations of the 3D Rayleigh–Taylor instability using this scheme. The numerical solutions are compared to (a) the exact 2D solution in the linear regime and (b) numerical solutions using the TVD scheme and the front tracking method. The computational program is used to study the evolution of a single bubble and 3D bubble merger, i.e., the nonlinear evolution of a single mode and the process of nonlinear mode–mode interaction.