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Abstracts of Papers to Appear

AN INTEGER LATTICE REALIZATION OF LAX SCHEME FOR TRANSPORT PROCESS IN MULTIPLE COMPONENT FLUID FLOWS. Sauro Succi,* Hudong Chen,† Chris Teixeira,† Gino Bella,‡ A. De Maio,‡ and Kim Molvig.§ **Istituto Applicazioni Calcolo, 137 Viale Policlinico, Rome 00144, Italy; †Exa Corporation, 125 Cambridge Park Drive, Cambridge, Massachusetts 02140; ‡Mechanical Engineering Department, University of Rome "Tor Vergata," Rome, Italy; and §Nuclear Engineering Department, Massachusetts Institute of Technology, Memorial Drive, Cambridge, Massachusetts.*

A Lax–Wendroff-like finite-difference representation for the transport of multiple chemical components is formulated via integer variables. This representation ensures exactly the desired conservation laws at all times, and achieves low numerical diffusivity. The algorithm requires less memory as compared to its floating-point predecessor, hence *much* less than standard lattice gas and lattice Boltzmann methods to date. Analytical and numerical studies demonstrate that the algorithm is stable under subsonic conditions.

AN SPH PROJECTION METHOD. Sharen J. Cummins* and Murray Rudman.† **Department of Mathematics and Statistics, Monash University, Clayton, Victoria 3168, Australia; and †CSIRO Building Construction and Engineering, Highett, Victoria 3122, Australia.* E-mail: sharen@groucho.maths.monash.edu.au, Murray.Rudman@dbce.csiro.au.

A new formulation is introduced for enforcing incompressibility in smoothed particle hydrodynamics (SPH). The method uses a fractional step with the velocity field integrated forward in time without enforcing incompressibility. The resulting intermediate velocity field is then projected onto a divergence-free space by solving a pressure Poisson equation derived from an approximate pressure projection. Unlike earlier approaches used to simulate incompressible flows with SPH, the pressure is not a thermodynamic variable and the Courant condition is based only on fluid velocities and not on the speed of sound. Although larger time steps can be used, the solution of the resulting elliptic pressure Poisson equation increases the total work per time step. Efficiency comparisons show that the projection method has a significant potential to reduce the overall computational expense compared to weakly compressible SPH, particularly as the Reynolds number, Re is increased. Simulations using this SPH projection technique show good agreement with finite-difference solutions for a vortex spin-down and Rayleigh–Taylor instability. The results, however, indicate that the use of an approximate projection to enforce incompressibility leads to error accumulation in the density field.

A DISCONTINUOUS GALERKIN METHOD FOR THE VISCOUS MHD EQUATIONS. T. C. Warburton and G. E. Karniadakis. *Center for Fluid Mechanics, Division of Applied Mathematics, Brown University, Providence, Rhode Island 02912.*

We present a new high-order method for the unsteady viscous MHD equations in two- and three-dimensions. The two main features of this method are: (1) the discontinuous Galerkin projections for both the advection and diffusion components, and (2) the polymorphic spectral/*hp* elements for unstructured and hybrid discretizations. An orthogonal spectral basis written in terms of Jacobi polynomials is employed, which results in a matrix-free algorithm and thus high computational efficiency. We present several results that document the high-order accuracy of the method, and perform a systematic *p*-refinement study of the compressible Orszag–Tang vortex as well as simulations of plasma flow past a circular cylinder. The proposed method, which can be thought of as a high-order

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extension of the finite volume technique, is suitable for direct numerical simulations of MHD turbulence as well as for other traditional MHD applications.

A Lattice Boltzmann Scheme for Incompressible Multiphase Flow and Its Application in Simulation of Rayleigh–Taylor Instability. Xiaoyi He, Shiyi Chen, and Raoyang Zhang. *Los Alamos National Laboratory, Los Alamos, New Mexico 87545.*

In this paper, we propose a new lattice Boltzmann scheme for simulation of multiphase flow in the nearly incompressible limit. The new scheme simulates fluid flows based on distribution functions. The interfacial dynamics, such as phase segregation and surface tension, are modeled by incorporating molecular interactions. The lattice Boltzmann equations are derived from the continuous Boltzmann equation with appropriate approximations suitable for incompressible flow. The numerical stability is improved by reducing the effect of numerical errors in calculation of molecular interactions. An index function is used to track interfaces between different phases. Simulations of the two-dimensional Rayleigh–Taylor instability yield satisfactory results. The interface thickness is maintained at 3–4 grid spacings throughout simulations without artificial reconstruction steps.

Fast Tree-Based Redistancing for Level Set Computations. John Strain. *Department of Mathematics, University of California—Berkeley, 970 Evans Hall, #3840, Berkeley, California 94720-3840.*

Level set methods for moving interface problems require efficient techniques for transforming an interface to a globally defined function whose zero set is the interface, such as the signed distance to the interface. This paper presents efficient algorithms for this “redistancing” problem. The algorithms use quadtrees and triangulation to compute global approximate signed distance functions. A quadtree mesh is built to resolve the interface, and the vertex distances are evaluated exactly with a robust search strategy to provide both continuous and discontinuous interpolants. Given a polygonal interface with N elements, our algorithms run in $O(N)$ space and $O(N \log N)$ time. Two-dimensional numerical results show they are highly efficient in practice.