Journal of Computational Physics **179,** 736–737 (2002)
doi:10.1006/jcph.2002.7114

Abstracts of Papers to Appear

Computation of Multiphase Mixture Flows with Compressibility Effects. Sankaran Venkateswaran,* Jules W. Lindau,† Robert F. Kunz,† and Charles L. Merkle.* *University of Tennessee, Tullahoma, Tennessee 37388; and †The Pennsylvania State University Applied Research Lab, Pennsylvania 16804.

A time-marching computational fluid dynamics method is developed and applied to the computation of multiphase mixture flows. The model accounts for finite acoustic speeds in the constituent phases, which typically lead to transonic/supersonic flow and associated compressibility phenomena such as shock formation in the mixture region. Preconditioning or artificial compressibility methods are devised using perturbation theory to insure that the method retains efficiency and accuracy in both the incompressible and compressible flow regimes. The resulting algorithm is incorporated within an existing multiphase code, and several representative applications are used to demonstrate the capabilities of the method. In particular, our results suggest that the present compressible formulation provides an improved description of cavitation dynamics compared with previous incompressible computations.

A Finite Difference Domain Decomposition Method Using Local Corrections for the Solution of Poisson's Equation. Gregory T. Balls* and Phillip Colella.† *Computer Science Division, University of California, Berkeley, California 94720; and †Applied Numerical Algorithms Group, Lawrence Berkeley National Laboratory, Berkeley, California 94720.

We present a domain decomposition method for computing finite difference solutions to the Poisson equation with infinite domain boundary conditions. Our method is a finite difference analogue of Anderson's Method of Local Corrections. The solution is computed in three steps. First, fine-grid solutions are computed in parallel using infinite domain boundary conditions on each subdomain. Second, information is transferred globally through a coarse-grid representation of the charge, and a global coarse-grid solution is found. Third, a fine-grid solution is computed on each subdomain using boundary conditions set with the global coarse solution, corrected locally with fine-grid information from nearby subdomains. There are three important features of our algorithm. First, our method requires only a single iteration between the local fine-grid solutions and the global coarse representation. Second, the error introduced by the domain decomposition is small relative to the solution error obtained in a single-grid calculation. Third, the computed solution is second-order accurate and only weakly dependent on the coarse-grid spacing and the number of subdomains. As a result of these features, we are able to compute accurate solutions in parallel with a much smaller ratio of communication to computation than more traditional domain decomposition methods. We present results to verify the overall accuracy, confirm the small communication costs, and demonstrate the parallel scalability of the method.

A Continuation and Bifurcation Technique for Navier–Stokes Flows. J. Sanchez,* F. Marques,* and J. M. Lopez.† *Departament de Física Aplicada, Universitat Politècnica de Catalunya, 08034 Barcelona, Spain; and †Department of Mathematics and Statistics, Arizona State University, Tempe, Arizona 85287-1804.

An efficient numerical bifurcation and continuation method for the Navier–Stokes equations in cylindrical geometries is presented and applied to a nontrivial fluid dynamics problem, the flow in a cylindrical container driven by differential rotation. The large systems that result from discretizing the Navier–Stokes equations, especially in regimes where inertia is important, necessitate the use of iterative solvers which in turn need preconditioners. We use incomplete LU as an effective preconditioner for such systems and show the significant gain in efficiency

0021-9991/02 $35.00

when an incomplete LU of the full Jacobian is used instead of using only the Stokes operator. The computational cost, in terms of CPU time, grows with the size of the system (i.e., spatial resolution) according to a power law with exponent around 1.7, which is very modest compared to direct methods, indicating the appropriateness of the schemes for large nonlinear partial differential equation problems.

Creation of Spatial Charge Separation in Plasmas with Rigorously Charge-Conserving Local Electromagnetic Field Solvers. C. Othmer,* U. Motschmann,† and K. H. Glassmeier.* *Institute for Geophysics and Meteorology, Technical University of Braunschweig, Braunschweig, Germany; and †Institute for Theoretical Physics, Technical University of Braunschweig, Braunschweig, Germany.

Charge-conserving local field solvers are widely used in today's electromagnetic plasma simulations. As in such codes the charge does not appear explicitly, the injection of new particles into the computational volume and their removal upon reaching the boundaries requires some cautiousness. While for quasineutral plasmas a particle injection in accordance with charge conservation can be realized quite easily, the injection of nonneutral plasmas with spatially separated electron and ion sources might lead to the emergence of unwanted divergences in the electric field. With a three-dimensional charge-conserving electromagnetic plasma simulation, we evaluate several injection schemes of nonneutral plasmas and present a method that rigorously respects conservation of charge and thus allows injection of nonneutral plasmas without producing unwanted divergences in the electric field.

Finite Difference Schemes for Incompressible Flow Based on Local Pressure Boundary Conditions. Hans Johnston* and Jian-Guo Liu.† *Department of Mathematics, University of Michigan, Ann Arbor, Michigan, 48109; and †Institute for Physical Science and Technology and Department of Mathematics, University of Maryland, College Park, Maryland, 20742.

In this paper we discuss the derivation and use of local pressure boundary conditions for finite difference schemes for the unsteady incompressible Navier–Stokes equations in the velocity–pressure formulation. Their use is especially well suited for the computation of moderate to large Reynolds number flows. We explore the similarities between the implementation and use of local pressure boundary conditions and local vorticity boundary conditions in the design of numerical schemes for incompressible flow in 2D. In their respective formulations, when these local numerical boundary conditions are coupled with a fully explicit convectively stable time stepping procedure, the resulting methods are simple to implement and highly efficient. Unlike the vorticity formulation, the use of the local pressure boundary condition approach is readily applicable to 3D flows. The simplicity of the local pressure boundary condition approach and its easy adaptation to more general flow settings make the resulting scheme an attractive alternative to the more popular methods for solving the Navier–Stokes equations in the velocity–pressure formulation. We present numerical results of a second-order finite difference scheme on a nonstaggered grid using local pressure boundary conditions. Stability and accuracy of the scheme applied to Stokes flow is demonstrated using normal mode analysis. Also described is the extension of the method to variable density flows.