JOURNAL OF COMPUTATIONAL PHYSICS **146,** 775–776 (1998)
ARTICLE NO. CP986109

Abstracts of Papers to Appear

DESIGNING AN EFFICIENT SOLUTION STRATEGY FOR FLUID FLOWS. II. STABLE HIGH-ORDER CENTRAL FINITE DIFFERENCE SCHEMES ON COMPOSITE ADAPTIVE GRIDS WITH SHARP SHOCK RESOLUTION. Margot Gerritsen and Pelle Olsson. *Department of Engineering Science, University of Auckland, Auckland, New Zealand.* E-mail: gerritsen@auckland.ac.nz.

A simple and efficient solution strategy is designed for fluid flows governed by the compressible Euler equations. It is constructed from a stable high-order central finite difference scheme on structured composite adaptive grids. This basic framework is suitable for solving smooth flows on complicated domains and is easily extendible with extra tools to handle specific flow problems. The stable high-order central difference scheme is mathematically formulated using a recently derived semi-discrete energy method for initial-boundary value problems. The high order of accuracy reduces the number of grid points required in smooth parts of the flow which leads to efficiency in both computational time and memory. A local grid adaptation technique is used to increase the grid density where required. Extra tools are developed for the sharp resolution of shocks. The grids are refined in the shock regions to retain accuracy. On the fine grids in these regions, an effective scalar artificial viscosity term is added to suppress spurious oscillations generated by the high-order central difference method. The location and orientation of shocks is determined by an easy-to-implement wavelet-based detection algorithm. The overhead of the composite adaptive grid method and detection algorithm is negligible compared to the computational kernel. The local grid adaptation with the high-order scheme is shown to increase computational efficiency. The resolution of shocks is sharp.

THE FAST CONSTRUCTION OF EXTENSION VELOCITIES IN LEVEL SET METHODS. D. Adalsteinsson and J. A. Sethian. *Department of Mathematics and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.* E-mail: sethian@math.berkeley.edu.

Level set techniques are numerical techniques for tracking the evolution of interfaces. They rely on two central embeddings; first, the embedding of the interface as the zero level set of a higher dimensional function and, second, the embedding (or extension) of the interface's velocity to this higher dimensional level set function. This paper applies Sethian's fast marching method, which is a very fast technique for solving the eikonal and related equations, to the problem of building fast and appropriate extension velocities for the neighboring level sets. Our choice and construction of extension velocities serves several purposes. First, it provides a way of building velocities for neighboring level sets in the cases where the velocity is defined only on the front itself. Second, it provides a subgrid resolution in some cases not present in the standard level set approach. Third, it provides a way to update an interface according to a given velocity field prescribed on the front in such a way that the signed distance function is maintained, and the front is never re-initialized; this is valuable in many complex simulations. In this paper, we describe the details of such implementations, together with speed and convergence tests and applications to problems in visibility relevant to semi-conductor manufacturing and thin film physics.

AN ADAPTIVE FINITE ELEMENT METHOD FOR MAGNETOHYDRODYNAMICS. H. R. Strauss and D. W. Longcope. *Courant Institute of Mathematical Sciences, New York University, New York, New York 10012.* E-mail: strauss@cims.nyu.edu.

A finite element discretization for two-dimensional MHD is described. The elements are triangles with piecewise linear basis functions. The main computational difficulty is the accurate calculation of the current. The most effective solution is to employ a current–vorticity advection formulation of the equations. Acceptable results can

0021-9991/98 $25.00

also be obtained with a two-step calculation of the current from the vector potential. Mesh operations are described to reconnect and refine the mesh adaptively in the vicinity of nearly singular currents to improve magnetic flux conservation. Example computations of the coalescence instability, tilt mode, and divertor tokamak equilibrium, validating and illustrating the method, are presented. The simulations show the formation of current sheets, with the current density increasing exponentially in time. During this increase, the grid of initially $\sim 10^4$ points adapts to provide resolution comparable to a uniform grid of up to 1.6×10^8 grid points.

ON THE USE OF WAVELETS IN COMPUTATIONAL COMBUSTION. R. Prosser and R. S. Cant. *CFD Laboratory, University Engineering Department, Trumpington Street, Cambridge CB2 1PZ, United Kingdom.* E-mail: rs10@eng.cam.ac.uk.

The numerical simulation of combustion remains a challenging task. Flames are often thin and occupy a relatively small volume within the domain of interest. Nevertheless all of the combustion chemistry and much of the associated molecular transport takes place within the flame itself, giving rise to a structure that must be resolved if the simulated flame response is to be captured accurately. The present work examines the use of a wavelet-based method in this context. A spatial discretisation scheme using biorthogonal wavelets is presented and is applied to a test problem involving flame propagation in a representative fuel–air mixture, in which the chemistry is treated using a standard four-step reduced reaction mechanism. A novel and elegant boundary treatment is adopted in the wavelet scheme to enable the implementation of physically realistic boundary conditions. Results show that the wavelet scheme is stable and accurate and, moreover, is able to exploit the natural data-compression properties of wavelets to represent the solution using a fraction of the storage required for more conventional methods.

A DOMAIN DECOMPOSITION METHOD FOR THE EXTERIOR HELMHOLTZ PROBLEM. Romeo F. Susan-Resiga and Hafiz M. Atassi. *Department of Aerospace and Mechanical Engineering, University of Notre Dame, Notre Dame, Indiana 46556.* E-mail: resiga@light.ame.nd.edu, atassi@carmen.ame.nd.edu.

A new domain decomposition method is presented for the exterior Helmholtz problem. The nonlocal Dirichlet-to-Neumann (DtN) map is used as a nonreflecting condition on the outer computational boundary. The computational domain is divided into nonoverlapping subdomains with Sommerfeld-type conditions on the adjacent subdomain boundaries to ensure uniqueness. An iterative scheme is developed, where independent subdomain boundary-value problems are obtained by applying the DtN operator to values from the previous iteration. The independent problems are then discretized with finite elements and can be solved concurrently. Numerical results are presented for a two-dimensional model problem, and both the solution accuracy and convergence rate are investigated.