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Abstracts of Papers to Appear

RECONSTRUCTING VOLUME TRACKING. William J. Rider* and Douglas B. Kothe†. **Applied Theoretical and Computational Physics Division, Hydrodynamic Methods Group (X-HM), †Materials Science and Technology Division, Structure/Property Relations Group (MST-8), Los Alamos National Laboratory, Los Alamos, New Mexico, 87545*. E-mail: wjr@lanl.gov, dbk@lanl.gov.

A new algorithm for the volume tracking of interfaces in two dimensions is presented. The algorithm is based upon a well-defined, second-order geometric solution of a volume evolution equation. The method utilizes local discrete material volume and velocity data to track interfaces of arbitrarily complex topology. A linearity-preserving, piecewise linear interface geometry approximation ensures that solutions generated retain second-order spatial accuracy. Second-order temporal accuracy is achieved by virtue of a multidimensional unsplit time integration scheme. We detail our geometrically based solution method, in which material volume fluxes are computed systematically with a set of simple geometric tasks. We then interrogate the method by testing its ability to track interfaces through large, controlled topology changes, whereby an initially simple interface configuration is subjected to vortical flows. Numerical results for these strenuous test problems provide evidence for the algorithm's improved solution quality and accuracy.

CASTOR: NORMAL-MODE ANALYSIS OF RESISTIVE MHD PLASMAS. W. Kerner,* J. P. Goedbloed,† G. T. A. Huysmans,* S. Poedts,† and E. Schwarz‡. **JET Joint Undertaking, Abingdon, Oxfordshire OX143EA, United Kingdom; †FOM Institute for Plasma Physics Rijnhuizen, Nieuwegein, The Netherlands; ‡ MPI für Plasmaphysik, EURATOM Ass. D-85748 Garching, Germany.* E-mail: Wolfgang.kerner@jet.uk.

The CASTOR (complex Alfvén spectrum of toroidal plasmas) code computes the entire spectrum of normal-modes in resistive MHD for general tokamak configurations. The applied Galerkin method, in conjunction with a Fourier finite-element discretisation, leads to a large scale eigenvalue problem $\mathbf{A}x = \lambda\mathbf{B}x$, where $\mathbf{A}$ is a nonself-adjoint matrix.

THE BLACK BOX MULTIGRID NUMERICAL HOMOGENIZATION ALGORITHM. J. David Moulton, Joel E. Dendy Jr., and James M. Hyman. *Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545*. E-mail: moulton@lanl.gov.

In mathematical models of flow through porous media, the coefficients typically exhibit severe variations in two or more significantly different length scales. Consequently, the numerical treatment of these problems relies on a *homogenization* or *upscaling* procedure to define an approximate coarse-scale problem that adequately captures the influence of the fine-scale structure. Inherent in such a procedure is a compromise between its computational cost and the accuracy of the resulting coarse-scale solution. Although techniques that balance the conflicting demands of accuracy and efficiency exist for a few specific classes of fine-scale structure (e.g., fine-scale periodic), this is not the case in general. In this paper we propose a new, efficient, numerical approach for the *homogenization* of the permeability in models of single-phase saturated flow. Our approach is motivated by the observation that multiple length scales are captured automatically by robust multilevel iterative solvers, such as Dendy's *black box multigrid*. In particular, the operator-induced variational coarsening in black box multigrid produces coarse-grid operators that capture the essential coarse-scale influence of the medium's fine-scale structure. We derive an explicit local, cell-based, approximate expression for the symmetric, 2×2 homogenized permeability tensor that

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is defined implicitly by the black box coarse-grid operator. The effectiveness of this black box multigrid numerical homogenization method is demonstrated through numerical examples.

NUMERICAL PRESERVATION OF SYMMETRY PROPERTIES OF CONTINUUM PROBLEMS. E. J. Caramana and P. P. Whalen. *Hydrodynamic Methods Group, Applied Theoretical and Computational Physics Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.* E-mail: ejc@lanl.gov.

We investigate the problem of perfectly preserving a symmetry associated naturally with one coordinate system when calculated in a different coordinate system. This allows a much wider range of problems that may be viewed as perturbations of the given symmetry to be investigated. We study the problem of preserving cylindrical symmetry in two-dimensional Cartesian geometry and spherical symmetry in two-dimensional cylindrical geometry. We show that this can be achieved by a simple modification of the gradient operator used to compute the force in a staggered grid Lagrangian hydrodynamics algorithm. In the absence of the supposed symmetry we show that the new operator produces almost no change in the results because it is always close to the original gradient operator. Our technique thus results in a subtle manipulation of the spatial truncation error in favor of the assumed symmetry but only to the extent that it is naturally present in the physical situation. This not only extends the range of previous algorithms and the use of new ones for these studies, but for spherical or cylindrical calculations it reduces the sensitivity of the results to grid setup with equal angular zoning that has heretofore been necessary with these problems.

A UNIFIED METHOD FOR COMPUTING INCOMPRESSIBLE AND COMPRESSIBLE FLOWS IN BOUNDARY-FITTED COORDINATES. Hester Bijl and Pieter Wesseling. *J. M. Burgers Center and TU Delft, Mekelweg 4, 2628 CD Delft, The Netherlands.* E-mail: h.bijl@math.tudelft.nl.

A unified method for computing incompressible and compressible flows with Mach-uniform accuracy and efficiency is described. The method is equally applicable to stationary and nonstationary flows. A pressure-based discretisation on a staggered grid in general boundary-fitted coordinates is used for the Euler equations. Extension to Navier–Stokes is straightforward. Dimensionless variables that remain finite for all Mach numbers are used. Mach number independent accuracy and efficiency is shown by numerical experiments.