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Abstracts of Papers to Appear

TRANSPORT OF MAGNETIC FLUX IN AN ARBITRARY COORDINATE ALE CODE. Robert E. Peterkin Jr., Michael H. Frese, and Carl R. Sovinec. *Directed Energy Directorate, Air Force Research Laboratory: Phillips Lab, Kirtland AFB, New Mexico 87117.* E-mail: bob@ppws07.plk.af.mil.

We illustrate a new technique for computing the time-evolution of magnetic flux on a generally nonorthogonal computational grid of a time-dependent, arbitrary Lagrangian–Eulerian magnetohydrodynamics (MHD) simulation code and apply this technique to some classical MHD test problems. For a nontrivial application, we demonstrate the power of this technique for the interesting problem of compact toroid translation between a pair of converging conical electrodes.

A BLOCK PSEUDOSPECTRAL METHOD FOR MAXWELL'S EQUATIONS. I. ONE-DIMENSIONAL CASE. Tobin A. Driscoll and Bengt Fornberg. *Department of Applied Mathematics, University of Colorado, Boulder, Colorado 80309.* E-mail: tad@colorado.edu, fornberg@colorado.edu.

A block pseudospectral (BPS) method is proposed as a new way to couple pseudospectral discretizations across interfaces in computations for a linear hyperbolic system. The coupling is achieved via discretized derivative-matching conditions obtained from the system. Compared to the standard technique of imposing compatibility conditions based on characteristics of the system, the BPS method offers better stability and accuracy, especially in the case where equation coefficients are discontinuous. Computational examples for Maxwell's equations in nonhomogeneous media demonstrate that BPS retains high accuracy over times that are orders of magnitude larger than those for not only low-order methods (such as Yee's), but also high-order methods, such as characteristic-based spectral elements.

EXACT INTEGRATIONS OF POLYNOMIALS AND SYMMETRIC QUADRATURE FORMULAS OVER ARBITRARY POLYHEDRAL GRIDS. Yen Liu and Marcel Vinokur. *NASA Ames Research Center, Moffett Field, California 94035.* E-mail: liu@nas.nasa.gov.

This paper is concerned with two important elements in the high-order accurate spatial discretization of finite-volume equations over arbitrary grids. One element is the integration of basis functions over arbitrary domains, which is used in expressing various spatial integrals in terms of discrete unknowns. The other consists of quadrature approximations to those integrals. Only polynomial basis functions applied to polyhedral and polygonal grids are treated here. Nontriangular polygonal faces are subdivided into a union of planar triangular facets, and the resulting triangulated polyhedron is subdivided into a union of tetrahedra. The straight line segment, triangle, and tetrahedron are thus the fundamental shapes that are the building blocks for all integrations and quadrature approximations. Integrals of products up to the fifth order are derived in a unified manner for the three fundamental shapes in terms of the position vectors of vertices. Results are given both in terms of tensor products and products of Cartesian coordinates. The exact polynomial integrals are used to obtain symmetric quadrature approximations of any degree of precision up to five for arbitrary integrals over the three fundamental domains. Using a coordinate-free formulation, simple and rational procedures are developed to derive virtually all quadrature formulas, including some previously unpublished. Four symmetry groups of quadrature points are introduced to derive Gauss formulas, while their limiting forms are used to derive Lobatto formulas. Representative Gauss and Lobatto formulas are tabulated. The relative efficiency of their application to polyhedral and polygonal grids is detailed. The extension to higher degrees of precision is discussed.

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THE FINITE ELEMENT DISCRETIZATION FOR STREAM-FUNCTION PROBLEMS ON MULTIPLY CONNECTED DOMAINS.
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The no-normal-flow condition states that the stream-function is constant at solid boundaries. For multiply connected domains these (unknown) constants differ per boundary and must be determined from integral conditions. This complicates discretization and solution of the problem considerably. In this paper we describe a simple, elegant, and systematic way for solving this problem within the context of a finite element discretization and apply our ideas to global ocean circulation simulation.

ON PERFORMANCE OF METHODS WITH THIRD- AND FIFTH-ORDER COMPACT UPWIND DIFFERENCING.
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The difference schemes for fluid dynamics type of equations based on third- and fifth-order compact upwind differencing (CUD) are considered. To validate their properties following from a linear analysis, calculations were carried out using the inviscid and viscous Burgers' equation as well as the compressible Navier–Stokes equation written in the conservative form for curvilinear coordinates. In the latter case, transonic cascade flow was chosen as a representative example. The performance of the CUD methods was estimated by investigating mesh convergence of the solutions and comparing with the results of second-order schemes. It is demonstrated that the oscillation-free steep gradients solutions obtained without using smoothing techniques can provide considerable increase of accuracy even when exploiting coarse meshes.