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Abstracts of Papers to Appear

SEMI-LAGRANGIAN METHODS FOR LEVEL SET EQUATIONS. John Strain. *Department of Mathematics, University of California, 970 Evans Hall #3840, Berkeley, California 94720-3840.* E-mail: strain@math.berkeley.edu.

A new numerical method for solving geometric moving interface problems is presented. The method combines a level set approach and a semi-Lagrangian time-stepping scheme which is explicit yet unconditionally stable. The combination decouples each mesh point from the others and the time step from the CFL stability condition, permitting the construction of methods which are efficient, adaptive, and modular. Analysis of a linear one-dimensional model problem suggests a surprising convergence criterion which is supported by heuristic arguments and confirmed by an extensive collection of two-dimensional numerical results. The new method computes correct viscosity solutions to problems involving geometry, anisotropy, curvature, and complex topological events.

THREE-DIMENSIONAL STABILITY ANALYSIS OF FREE SURFACE FLOWS: APPLICATION TO FORWARD DEFORMABLE ROLL COATING. M. S. Carvalho and L. E. Scriven. *Coating Process Fundamentals Program, Center for Interfacial Engineering and Department of Chemical Engineering & Material Science, University of Minnesota, Minneapolis, Minnesota 55455.*

Coating flows, with a few exceptions, need to be steady and two-dimensional flows. Moreover, the flow states need to be stable at the operating conditions chosen. The goal of stability analysis of coating flows is to determine the region in the parameter space at which the flow is stable and therefore the coated layer uniform. To determine the stability of liquid flows, a generalized eigenvalue problem must be solved. This paper describes a formulation for a linear, three-dimensional stability analysis of free surface flows that reduces the size of the eigenproblem, decreasing the computational cost, with no further simplification, when compared with the methods reported in the literature. This formulation is used to study the instability that arises in film-splitting flows between counter-rotating rolls in a deformable gap. This flow instability leads to nonuniform coating characterized by a wavy thickness profile in the transverse direction. This patterning is usually refered as “ribs.” This type of instability has received a lot of attention in the literature. However, all previous work has addressed the flow between two rigid rolls. Often, in practice, one of the rolls of a pair is covered by a layer of elastomer. The deformation of the roll cover alters the conformation of the gap, the pressure gradient at the film-split meniscus, and, consequently, the critical parameters at the onset of ribbing change. The results indicate how a deformable cover can be used to delay the onset of ribbing in forward-roll coating.

AN EFFICIENT METHOD FOR THE SOLUTION OF THE INCOMPRESSIBLE NAVIER–STOKES EQUATIONS IN CYLINDRICAL GEOMETRIES. M. Manna* and A. Vacca.† **Dipartimento di Ingegneria Meccanica per l’Energetica, Universitá di Napoli ‘Federico II’, Naples, Italy; and †Dipartimento di Ingegneria Civile, Seconda Universitá di Napoli, Naples, Italy.*

The article presents a fast pseudo-spectral Navier–Stokes solver for cylindrical geometries, which is shown to possess exponential rate of decay of the error. The formulation overcomes the issues related to the axis singularity, by employing in the radial direction a special set of collocation points together with standard Chebyshev polynomials. A multidomain technique with patching interfaces yields significant improvements in the conditioning of the algebraic problems arising from the discretization procedure and allows for an enhanced near-wall resolution of wall-bounded shear flows. The elliptic kernel enjoys the efficiency of an analytic expansion of the harmonic extension. The method is tested by computing the formation of Taylor vortices in a rotating Couette flow for

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both axisymmetric and nonaxisymmetric configurations. A direct numerical simulation of a turbulent pipe flow at moderate Reynolds number demonstrates the effectiveness of the method in as much as the axis singularity is concerned. Results compare well with reference experimental and numerical data.

TREE METHODS FOR MOVING INTERFACES. John Strain. *Department of Mathematics, University of California, 970 Evans Hall #3840, Berkeley, California 94720-3840.*

Fast adaptive numerical methods for solving moving interface problems are presented. The methods combine a level set approach with frequent redistancing and semi-Lagrangian time-stepping schemes which are explicit yet unconditionally stable. A quadtree mesh is used to concentrate computational effort on the interface, so the methods move an interface with N degrees of freedom in $O(N \log N)$ work per time step. Efficiency is increased by taking large time steps even for parabolic curvature flows. The methods compute accurate viscosity solutions to a wide variety of difficult moving interface problems involving merging, anisotropy, faceting, and curvature.

A HIGH-ORDER WENO FINITE DIFFERENCE SCHEME FOR THE EQUATIONS OF IDEAL MAGNETOHYDRODYNAMICS. Guang-Shan Jiang* and Cheng-chin Wu.† **Courant Institute, 251 Mercer St., New York, New York 10012; and †Department of Physics and Astronomy, University of California, Los Angeles, California 90095.*

We present a high-order accurate weighted essentially nonoscillatory (WENO) finite difference scheme for solving the equations of ideal magnetohydrodynamics (MHD). This scheme is a direct extension of a WENO scheme, which has been successfully applied to hydrodynamic problems. The WENO scheme follows the same idea of an essentially nonoscillatory (ENO) scheme with an advantage of achieving higher order accuracy with fewer computations. Both ENO and WENO can be easily applied to two and three spatial dimensions by evaluating the fluxes dimension-by-dimension. Details of the WENO scheme as well as the construction of a suitable eigensystem, which can properly decompose various families of MHD waves and handle the degenerate situations, are presented. Numerical results are shown to perform well for the one-dimensional Brio–Wu Riemann problems, the two-dimensional Kelvin–Helmholtz instability problems, and the two-dimensional Orszag–Tang MHD vortex system. They also demonstrate the importance of maintaining the divergence free condition for the magnetic field in achieving numerical stability. The tests also show the advantages of using the higher order scheme. The new fifth-order WENO MHD code can attain an accuracy comparable with that of the second-order schemes with many fewer grid points.