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Abstracts of Papers to Appear in Future Issues

ENSURING WELL-POSEDNESS BY ANALOGY; STOKES PROBLEM AND BOUNDARY CONTROL FOR THE WAVE EQUATION. R. Glowinski. *University of Houston, Department of Mathematics, Houston, Texas 77204-3476, USA and Université Paris VI and CERFACS, France.*

In this article we give a comparative discussion of the finite element approximation of two partial differential equation problems. These two problems which are apparently quite unrelated are the Stokes problem for incompressible viscous flow and an exact boundary controllability problem for the wave equation. We show that straightforward discrete approximations to these problems yield approximate problems which are ill-posed. The analysis of the ill-posedness of the above problems shows an identical cause, namely the strong damping of the high frequency modes, beyond a critical wave number. From this analogy, a well-known cure for the discrete Stokes problem, i.e., using more accurate approximations for velocity than for pressure, provides a simple way to eliminate the ill-posedness of the discrete exact boundary controllability problem. Numerical examples concerning the control problem testify about the soundness of the new approach. To conclude this paper one takes advantage of the previous analysis to give a brief discussion of the wavelet approximation of the Stokes problem for Dirichlet boundary conditions.

ON THE GENERATION OF ORTHOGONAL POLYNOMIALS USING ASYMPTOTIC METHODS FOR RECURRENCE COEFFICIENTS. Andrew S. Clarke and Bernie Shizgal. *Department of Chemistry, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1.*

A set of orthogonal polynomials is defined by specifying an interval and a weight function. Any such set of polynomials satisfies a three term recurrence relation with coefficients α_n and β_n, which in turn satisfy coupled recurrence relations. If the polynomials do not belong to the set of *classical* polynomials, these recurrence relations are generally numerically unstable. In this paper, we consider the generation of several sets of orthogonal polynomials that are useful in the solution of different physical problems. We construct recurrence relations for the coefficients in the three term recurrence relations of these polynomials and study their numerical instability. Divergent asymptotic series for the recurrence coefficients are derived and used to obtain accurate approximations through the use of direct summation or continued fractions. A comparison of these approximate recurrence coefficients is made with the accurate values obtained with the use of multiple precision arithmetic.

LAGRANGIAN SOLUTION OF SUPERSONIC REAL GAS FLOWS. Ching-Yuen Loh and Meng-Sing Liou. *Internal Fluid Mechanics Division, NASA Lewis Research Center, Cleveland, Ohio 44135, USA.*

This paper details the procedure of the real-gas Riemann solution in the Lagrangian approach originally proposed by Loh and Hui for perfect gases. The extension to real gases is nontrivial and requires substantial development of an exact real-gas Riemann solver for the Lagrangian form of conservation laws. The first-order Gudonov scheme is enhanced for accuracy by adding limited anti-diffuse terms according to Sweby. Extensive calculations were made to test the accuracy and robustness of the present real-gas Lagrangian approach, including complex wave interactions of different types. The accuracy for capturing 2D oblique waves and slipline is clearly demonstrated. In addition, we also show the real-gas effect in a generic engine nozzle.

AN ACCURATE SOLUTION OF THE POISSON EQUATION BY CHEBYSHEV COLLOCATION METHOD. H. Dang-Vu. *Institut de Mathématiques pures et appliquées, Université Pierre et Marie Curie, Paris, France*; C. Delcarte. *Equipe RAMSES, U.P.R. 293 du CNRS, Université Paris-Sud, Orsay, France.*

A new Chebyshev collocation method is presented for the 2D Poisson equation. The resolution of the mixed collocation τ equations leads to two quasi-tridiagonal systems which can be solved by standard techniques. Comparison of the results for the test problem $u(x, y) = \sin 4\pi x \sin 4\pi y$ with those computed by Haidvogel and Zang, using the matrix diagonalization method, indicates that our method would be more accurate at large N values.

DIRECT CALCULATION OF METRIC ENTROPY FROM TIME SERIES. Kevin M. Short. *Vitro Corporation, Advanced Technology Lab, 14000 Georgia Avenue, Silver Spring, Maryland 20906-2972, USA.*

In this paper we develop an algorithm which allows for a direct computation of the metric entropy from time series data. The approach is based on the original definition and enables us to use fine partitions and long sequence lengths. There is a discussion of the underlying theory, followed by an explanation of the computational approach, including methods of partitioning the data, computing the sequential distributions, and compactifying to reduce memory requirements. The approach is tested against periodic, random, and chaotic data for which the metric entropy is known analytically. Then the technique is applied to the Henon, Ikeda, Rossler, Lorenz, and Mackey–Glass attractors. The results compare well with those found by other techniques.

MASS MATRIX FORMULATION OF THE FLIP PARTICLE-IN-CELL METHOD. D. Burgess. *Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA*; D. Sulsky. *Department of Mathematics and Statistics, University of New Mexico, Albuquerque, New Mexico 87131, USA*; J. U. Brackbill. *Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA.*

A refinement of FLIP (Brackbill and Ruppel, *J. Comput. Phys.* **65**, 314 (1986)) is described which uses a mass matrix formulation to achieve greater accuracy and less numerical diffusion over the previous version. Without the refinement, there is a significant dissipation of energy in modeling elastic vibrations of a solid. Moreover, in modeling an initial flow discontinuity there are sub-grid-scale oscillations in the particle velocity field in the neighborhood of the discontinuity. These difficulties are eliminated using the mass matrix. In addition, the mass matrix formulation conserves kinetic energy, linear and angular momentum, and is Galilean invariant.

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CALCULATIONS OF AXISYMMETRIC STABILITY OF TOKAMAK PLASMAS WITH ACTIVE AND PASSIVE FEEDBACK. D. J. Ward, S. C. Jardin, and C. Z. Cheng. *Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08543, USA.*

Simulations of a vortex tube in unbounded, inviscid, incompressible fluid flow using three-dimensional vortex filament methods are presented. The numerical parameters that determine accuracy are investigated. Methods to deal with the truncated ends, which arise in the simulation of a part of a vortex tube, are developed. The nonmonotonic response of the vortex filament evolution using the vortex method to variation of core size is observed. The effect of a small torsion of a wave on vortex stretching is discussed. The long-time propagation of a periodic wave of constant helical shape along a vortex tube is illustrated.

COMPUTATIONAL CHAOS MAY BE DUE TO A SINGLE LOCAL ERROR. E. Adams. *Institut für Angewandte Mathematik, Universität Karlsruhe, Kaiserstrasse 12, W-7500 Karlsruhe, Germany*; W. F. Ames, W. Kühn, and W. Rufeger. *School of Mathematics, Georgia Institute of Technology, Atlanta, Georgia 30332, USA*; H. Spreuer. *Institut für Angewandte Mathematik, Universität Karlsruhe, Kaiserstrasse 12, W-7500 Karlsruhe, Germany.*

A new linear MHD stability code, NOVA-W, has been developed in order to study feedback stabilization of the axisymmetric mode in deformable tokamak plasmas. The NOVA-W code is a modification of the non-variational MHD stability code NOVA that includes the effects of resistive passive conductors and active feedback circuits. The vacuum calculation has been reformulated in terms of the perturbed poloidal flux to allow the inclusion of perturbed toroidal currents outside the plasma. The boundary condition at the plasma–vacuum interface relates the instability displacement to the perturbed poloidal flux. This allows a solution of the linear MHD stability equations with the feedback effects included. The passive stability predictions of the code have been tested both against a simplified analytic model and against a different numerical calculation for a realistic tokamak configuration. The comparisons demonstrate the accuracy of the NOVA-W results. Active feedback calculations are performed for the CIT tokamak design demonstrating the effect of varying the position of the flux loops that provide the measurements of vertical displacement. The results compare well with those computed earlier using a less efficient nonlinear code.

NUMERICAL STUDY OF WAVE PROPAGATION ON VORTEX FILAMENTS. Anmin Qi. *Department of Mathematics and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.*

Nonlinear ordinary differential equations and arbitrary difference methods are considered which satisfy conditions for the convergence of a sequence of difference solutions. This convergence does not prevent "diversions" of a computed difference solution, a property which is defined here. The occurrence of diversions is demonstrated in examples, namely the *restricted three body problem* and the Lorenz equations. This occurrence is practically unpredictable. In the applied literature, this property has been used to define "(dynamical) chaos." Therefore, chaos for solutions of ODEs is not necessarily a consequence of a sensitive dependency on the initial vector but, rather, may be due to a corresponding dependency on computational errors.

A COMPARISON OF THE CONTOUR SURGERY AND PSEUDO-SPECTRAL METHODS. Bernard Legras. *Laboratoire de Météorologie Dynamique du CNRS, École Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex 05, France*; David G. Dritschel. *Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge CB3 9EW, United Kingdom.*

Two very different numerical methods which have been used to simulate high Reynolds number two-dimensional flows are compared for the first time. One method, the pseudo-spectral method, is fundamentally based on the Eulerian description of fluid flow, and the other, the contour surgery method, is inherently Lagrangian. The former makes use of a continuous distribution of vorticity, while the latter, a theoretically inviscid method, makes use of a discrete distribution. A comparison is nevertheless attempted in a model problem wherein the initial vorticity distribution is continuous. We examine the stripping of an initially circular vortex by applied adverse shear in doubly-periodic geometry. The constraining geometry causes the flow to become very complex, placing great demands on both computational methods. The surprise is that as few as eight discrete levels of vorticity in contour surgery give results which are quantitatively close to those obtained by the pseudo-spectral method at high-resolution. Advantages and shortcomings of both methods are noted.

A CHEBYSHEV–LEGENDRE SPECTRAL METHOD FOR THE TRANSIENT SOLUTIONS OF FLOW PAST A SOLID SPHERE. Hoa D. Nguyen. *Idaho National Engineering Laboratory, EG & G Idaho, Inc., Idaho Falls, Idaho, USA*; Jacob N. Chung. *Department of Mechanical and Materials Engineering, Washington State University, Pullman, Washington.*

A full spectral model for the stream-function-vorticity formulation is developed for the solution of unsteady flow past a rigid sphere. To convert the governing partial differential equations to discrete form, Chebyshev and Legendre polynomials are employed to expand the vorticity and stream function in the radial and angular directions, respectively, together with a first-order, fully implicit, iterative scheme for time advancement. The solution to the system of discrete nonlinear equations is accomplished by LU decomposition in conjunction with the influence matrix to resolve the lack of vorticity boundary conditions. Owing to the global nature of the orthogonal trial functions, the present technique provides a means to achieve highly accurate results with a smaller number of unknowns than either traditional finite difference or finite element methods. Comparisons of numerical solutions with previous results show consistent trends as reported in studies dealing with Cartesian coordinates.

NOTES TO APPEAR

ELIMINATING BOUNDARY INDUCED ERRORS IN THE PSEUDO-CURRENT METHOD. Barry Marder. *Plasma Theory Division 1241, Sandia National Laboratories, P.O. Box 5800, Albuquerque, New Mexico 87185, USA.*

REMOVAL OF APPARENT SINGULARITY IN GRID COMPUTATIONS. J. P. Jakubovics. *Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom.*

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