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Abstracts of Papers to Appear in Future Issues

A FLUID-ION AND PARTICLE-ELECTRON MODEL FOR LOW-FREQUENCY PLASMA INSTABILITIES. P. M. Lyster. *Institute for Fusion Studies, The University of Texas at Austin, Austin, Texas 78712*; J.-N. Leboeuf. *Oak Ridge National Laboratory, Fusion Energy Division, Oak Ridge, Tennessee 37830.*

We have developed a hybrid (particle/fluid) computer code for the study of quasi-neutral micro-instabilities for inhomogeneous plasmas that are immersed in a magnetic field. The ions are treated in the fluid approximation, retaining perpendicular $\mathbf{E} \times \mathbf{B}$ and polarization drifts as well as the parallel momentum and ion temperature equations. The electrons are represented as particles with perpendicular $\mathbf{E} \times \mathbf{B}$ drifts and parallel kinetics, thus exactly describing the effects of trapped electrons and electron-wave resonances. The code may be used in the study of low frequency ($\omega < \Omega_i$ where $\Omega_i = eB/m_i c$) universal mode drift waves, ion-pressure-driven modes, or curvature-driven modes. At present we have implemented an electrostatic, two-dimensional, slab geometry version of the code. The model has been tested extensively for sound-wave propagation, the collisionless (universal mode) drift wave real frequency and growth rate, the η_i-mode real frequency and growth rate, and the fluctuation spectrum has been elucidated. As a nonlinear test case, we have also studied the nonlinear properties of the collisionless drift wave.

AN EFFICIENT SURFACE-INTEGRAL ALGORITHM APPLIED TO UNSTEADY GRAVITY WAVES. J. W. Dold. *School of Mathematics, University of Bristol, Bristol BS8 1TW, United Kingdom.*

A computationally fast method for calculating the unsteady motion of a surface on a two-dimensional fluid is described. Cauchy's integral theorem is used iteratively to solve Laplace's equation for successive time derivatives of the surface motion and time-stepping is performed using truncated Taylor series. This allows fairly large time-steps to be made for a given accuracy while the required number of spatial points is minimized by using high order differencing formulae. This reduces the overall number of required calculations. The numerical implementation of the method is found to be accurate and efficient. A fairly thorough examination of this implementation is carried out, revealing that high accuracies are often achievable using surprisingly few numerical surface points. Extensive calculations are also performed using modest computing resources. Some numerical instabilities are identified, although these would not usually be significant in practical calculations. A model analysis reveals that two of these instabilities can be eliminated by using suitable methods of time-stepping. Should the third "steep-wave instability" become significant, it is shown that it can be completely controlled by using high-order smoothing techniques, at little cost to accuracy. Using a routine to ensure asymptotic conservation of energy, this is confirmed by time-stepping a very steep (but stable) wave over thousands of wave-periods.

IMPLICIT FLUX LIMITING SCHEMES FOR PETROLEUM RESERVOIR SIMULATION. Martin Blunt and Barry Rubin. *BP Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex TW16 7LN, United Kingdom.*

Explicit total variation diminishing (TVD) numerical methods have been used in the past to give convergent, high order accurate solutions to hyperbolic conservation equations, such as those governing flow in oil reservoirs. To ensure stability there is a restriction on the size of time step that can be used. Many petroleum reservoir simulation problems have regions of fast flow away from sharp fronts, which means that this time step limitation makes explicit schemes less efficient than the best implicit methods. This work extends the theory of TVD schemes to both fully implicit and partially implicit methods. We use our theoretical results to construct schemes which are stable even for very large time steps. We show how to construct an adaptively implicit scheme which is nearly fully implicit in regions of fast flow, but which may be explicit at sharp fronts which are moving more slowly. In general these schemes are only first-order accurate in time overall, but locally may achieve second-order time accuracy. Results, presented for a one-dimensional Buckley–Leverett problem, demonstrate that these methods are more accurate than conventional implicit algorithms and more efficient than fully explicit methods, for which smaller time steps must be used. The theory is also extended to embrace mixed hyperbolic/parabolic (black oil) systems and example solutions to a radial flow equation are presented. In this case the time step is not limited by the high flow speeds at a small radius, as would be the case for an explicit solution. Moreover, the shock front is resolved more sharply than for a fully implicit method.

MAPPINGS AND ACCURACY FOR CHEBYSHEV PSEUDO-SPECTRAL APPROXIMATIONS. Alvin Bayliss. *Department of Engineering Sciences and Applied Mathematics, Robert R. McCormick School of Engineering and Applied Sciences, Northwestern University, Evanston, Illinois 60208*; Eli Turkel. *Department of Applied Mathematics, School of Mathematical Sciences, Sackler Faculty of Exact Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel.*

The effect of mappings on the approximation, by Chebyshev collocation, of functions which exhibit localized regions of rapid variation is studied. A general strategy is introduced whereby mappings are adaptively constructed which map specified classes of rapidly varying functions into low order polynomials which can be accurately approximated by Chebyshev polynomial expansions. A particular family of mappings constructed in this way is tested on a variety of rapidly varying functions similar to those occurring in applications. It is shown that the mapped function can be approximated much more accurately by Chebyshev polynomial approximations than in physical space or where mappings constructed from other strategies are employed. The effect on the approximation of introducing subdomains is studied. The accuracy of the pseudo-spectral approximation is very sensitive to the location of the interface, although this sensitivity is reduced when mappings are employed within the subdomains.

A STANDARD TEST SET FOR NUMERICAL APPROXIMATIONS TO THE SHALLOW WATER EQUATIONS IN SPHERICAL GEOMETRY. David L. Williamson. *The National Center for Atmospheric Research, Boulder, Colorado 80307*; John B. Drake. *Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831*; James J. Hack, Rüdiger Jakob, and Paul N. Swarztrauber. *The National Center for Atmospheric Research, Boulder, Colorado 80307.*

A suite of seven test cases is proposed for the evaluation of numerical methods intended for the solution of the shallow water equations in spheri-

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