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Abstracts of Papers to Appear in Future Issues

MULTICOMPONENT FLOW CALCULATIONS BY A CONSISTENT PRIMITIVE ALGORITHM. Smadar Karni. *Department of Mathematics, University of Michigan, Ann Arbor, Michigan 48109, U.S.A.*

The dynamics of inviscid multicomponent fluids may be modelled by the Euler equations, augmented by one (or more) additional species equation(s). Attempting to compute solutions for extended Euler models in conservation form, we show strong oscillations and other computational inaccuracies near material interfaces. These are due to erroneous pressure fluctuations generated by the conservative wave model. This problem does not occur in single component computations and arises only in the presence of several species. A nonconservative (primitive) Euler formulation is proposed, which results in complete elimination of the oscillations. The numerical algorithm uses small viscous perturbations to remove leading order conservation errors and is conservative to the order of numerical approximation. Numerical experiments show clean monotonic solution profiles, with acceptably small conservation error for shocks of weak to moderate strengths.

TIME-SYMMETRIC ADI AND CAUSAL RECONNECTION: STABLE NUMERICAL TECHNIQUES FOR HYPERBOLIC SYSTEMS ON MOVING GRIDS. M. Alcubierre and Bernard F. Schutz. *Department of Physics and Astronomy, University of Wales, College of Cardiff, P.O. Box 913, Cardiff CF1 3TH, Wales, United Kingdom.*

Moving grids are of interest in the numerical solution of hydrodynamical problems and in numerical ones relatively. We show that conventional integration methods for the simple wave equation in one and more than one dimension exhibit a number of instabilities on moving grids. We introduce two techniques, which we call *causal reconnection* and *time-symmetric ADI*, which together allow integration of the wave equation with absolute local stability in any number of dimensions on grids that may move very much faster than the wave speed and that can even accelerate. These methods allow very long time-steps, are fully second-order accurate, and offer the computational efficiency of operator-splitting. We develop causal reconnection first in the one-dimensional case; we find that a conventional implicit integration scheme that is unconditionally stable as long as the speed of the grid is smaller than that of the waves nevertheless turns unstable whenever the grid speed increases beyond this value. We introduce a notion of *local stability* for difference equations with variable coefficients. We show that, by "reconnecting" the computational molecule at each time-step in such a way as to ensure that its members at different time-steps are within one another's causal domains, one eliminates the instability, even if the grid accelerates. This permits very long time-steps on rapidly moving grids. The method extends in a straightforward and efficient way to more than one dimension. However, in more than one dimension, it is very desirable to use operator-splitting techniques to reduce the computational demands of implicit methods, and we find that standard schemes for integrating the wave equation—Lees' first and second alternating direction implicit (ADI) methods—go unstable for quite small grid velocities. Lees' first method, which is only first-order accurate on a shifting grid, has mild but nevertheless significant instabilities. Lees' second method, which is second-order accurate, is very unstable. By adopting a systematic approach to the design of ADI schemes, we develop a new ADI method that cures the instability for all velocities in any direction up to the wave speed. This scheme is uniquely defined by a simple physical principle: the ADI difference equations should be invariant under time-inversion. (The wave equation itself and the fully implicit difference equations satisfy this criterion, but neither of Lees' methods do.) This new time-symmetric ADI scheme is, as a bonus, second-order accurate. It is thus far more efficient than a fully implicit scheme, just as stable, and just as accurate. By implementing causal reconnection of the computational molecules, we extend the time-symmetric ADI scheme to arrive at a scheme that is second-order accurate, computationally efficient, and unconditionally locally stable for all grid speeds and long time-steps. We have tested the method by integrating the wave equation on a rotating grid, where it remains stable even when the grid speed at the edge is 15 times the wave speed. Because our methods are based on simple physical principles, they should generalize in a straightforward way to many other hyperbolic systems. We discuss briefly their application to general relatively and their potential generalization to fluid dynamics.

A "STRATIFIED" SPECTRAL MODEL FOR STABLE AND CONVECTIVE ATMOSPHERES. Kwing L. Chan. *Applied Research Corporation, Landover, Maryland 20785, U.S.A.*; H. G. Mayr. *NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771, U.S.A.*; J. G. Mengel. *Applied Research Corporation, Landover, Maryland 20785, U.S.A.*; I. Harris. *NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771, U.S.A.*

In our solar system, convective atmospheres are as common as those that are stable, and convective and stable regions sometimes coexist in the same atmosphere. There is a need to develop circulation models that can handle convection and stable-layer flows simultaneously and efficiently. This paper represents an approach to the construction of such a model. Taking advantages of the simplicity of implementing implicit time stepping in spectral models, we solve a non-hydrostatic, fully compressible version of the hydrodynamic equations without the time step restrictions imposed by acoustic and gravity waves. To simplify the nonlinear terms and to conserve the total mass and total angular momentum to round-off accuracy, we introduce a "stratified" approximation which limits the nonlinearity of the equations to quadratic. The linear terms remain intact so that all the linear waves are preserved. The set of assumptions made by the "stratified" approximation is a subset of those of the anelastic approximation. It offers more generality and accuracy while the computational overhead is relatively low. Tests are presented to illustrate the capabilities and advantages of the present model.

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KINETIC SIMULATION OF A TIME-DEPENDENT TWO-DIMENSIONAL PLASMA. W. N. G. Hitchon and E. R. Keiter. *Engineering Research Center for Plasma-Aided Manufacturing, University of Wisconsin-Madison, 1415 Johnson Dr., Madison, Wisconsin 53706, U.S.A.*

The distribution function of ions is calculated in a two-dimensional plasma with a rapidly expanding sheath, self-consistently with the electrostatic potential, ϕ. The numerical procedure consists of a direct solution of an integral form of the kinetic equation. This solution relies on the use of a simple form for the Green's function which describes the time-evolution of the distribution, which has previously been used in one spatial dimension and is here extended to two dimensions. The electron density n_e is assumed to be described by the Boltzmann relation, $n_e = n_0 \exp(e\Phi/\kappa T_e)$, allowing Poisson's equation to be solved for Φ self-consistently with the ion density. This procedure is applied to describe the plasma surrounding a "target" to which is rapidly applied a large negative potential, as occurs in plasma source ion implantation (PSII). The ion distribution striking the target is calculated to allow determination of the dose and depth profile.

A NEW NONSTATIONARY BOLTZMANN SOLVER IN SELF-CONSISTENT MODELLING OF DISCHARGE PUMPED PLASMAS FOR EXCIMER LASERS. D. Loffhagen. *Institut für Plasmaphysik, Universität Hannover, D-30167 Hannover, Germany*; R. Winkler. *Institut für Niedertemperatur-Plasmaphysik, D-17489 Greifswald, Germany.*

A self-consistent spatially homogeneous numerical model for discharge pumped excimer laser plasmas is presented with the inclusion of the nonstationary Boltzmann equation of the electrons. The nonstationary treatment of this equation (including electron–electron interaction) is based on the conventional two-term approximation and the quasi-stationary description of the anisotropic part of the velocity distribution. A detailed presentation of the new and very efficient iterative solution technique of the nonstationary electron kinetic equation is given and its integration into the complete model is described. First results of model calculations for a Ne/Xe/HCl mixture are reported in order to illustrate the new technique.