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Abstracts of Papers to Appear in Future Issues

FINITE ELEMENT NUMERICAL MODELING OF STATIONARY TWO-DIMENSIONAL MAGNETOSPHERE WITH DEFINED BOUNDARY. M. D. Kartalev, and M. S. Kaschiev, *Bulgarian Academy of Sciences, Sofia, 1113 Bulgaria*, D. K. Koitchev, *Sofia University "St. Kl. Ohridsky," Sofia, Bulgaria.*

A finite element numerical procedure is developed for two-dimensional modeling of stationary magnetosphere. The whole magnetic field is supposed to be a sum of given internal fields and a searched divergent-free and curl-free field of the magnetopause shielding current system. The boundary condition on the given boundary is the Neumann one on the magnetopause part of the computational region boundary and the Dirichlet condition on the segment part, closing this region at the tail. The algorithms used for automatic grid generation and grid transformation allow wide flexibility in determining the region shape and the assigned internal fields. Some numerical implementations not only demonstrate the method capabilities. In the frame of the two-dimensional approach these implementations could be considered as a tentative simulation of some typical features of magnetosphere magnetic field topology, which is intrinsically three-dimensional. The magnetopause geometry influence on the cusp inclination is shown. The impact of the northward and the flow-aligned field on dayside merging and tail asymmetry is aluminized. A two-dimensional approach to modeling the crosstail currents is proposed for the Earth-type and Uranus-type magnetospheres.

STRATEGIES FOR THE ACCURATE COMPUTATION OF POTENTIAL DERIVATIVES IN BOUNDARY ELEMENT METHOD: APPLICATION TO TWO-DIMENSIONAL PROBLEMS. Hajime Igarashi and Toshihisa Honma, *Department of Electrical Engineering, Faculty of Engineering, Hokkaido University, Sapporo, 060, Japan.*

This paper describes two strategies for the accurate computations of potential derivatives in boundary element methods. The first method regularizes the quasi singularity in a fundamental solution by referring the potential and its derivatives at the boundary point nearest to a calculation point in a domain. In the second method, a system of coupled equations for an unknown potential and its derivatives at a calculation point is solved to improve accuracy. Green's theorem unifies the derivation of the above methods, which are shown to be suitable for computer implementation. Numerical results show that the present methods considerably improve the accuracy in the computations of potential derivatives. The errors in the present methods are analyzed to evaluate their performance for general cases. Although this paper describes the regularization methods for only two-dimensional problems, it is suggested that those can be easily extended to three-dimensional problems.

ACCURATE FINITE DIFFERENCE METHODS FOR TIME-HARMONIC WAVE PROPAGATION. Isaac Harari, *Tel-Aviv University, Ramat Aviv, Israel.* Eli Turkel, *Tel-Aviv University, Ramat Aviv, Israel and Institute for Computer Applications in Science and Engineering, NASA Langley Research Center, Hampton, Virginia 23681, U.S.A.*

Finite difference methods for solving problems of time-harmonic acoustics are developed and analyzed. Multi-dimensional inhomogeneous problems with variable, possibly discontinuous, coefficients are considered, accounting for the effects of employing non-uniform grids. A weighted-average representation is less sensitive to transition in wave resolution (due to variable wave numbers or non-uniform grids) than the standard pointwise representation. Further enhancement in method performance is obtained by basing the stencils on generalizations of Padé approximation, or generalized definitions of the derivative, reducing spurious dispersion, anisotropy, and reflection, and by improving the representation of source terms. The resulting schemes have fourth-order accurate local truncation error on uniform grids and third order in the non-uniform case. Guidelines for discretization pertaining to grid orientation and resolution are presented.

MESH EFFECTS FOR ROSSBY WAVES. John K. Dukowicz, *Theoretical Division, Group T-3, Los Alamos National Laboratory, University of California, Los Alamos, New Mexico 87545, U.S.A.*

Dispersion relations are obtained for Rossby waves on Arakawa grids A–E. The discretization accuracy is compared for both inertia–gravity and Rossby waves in terms of "domains of accuracy" for a given level of percentage error. In particular, the B-grid appears to be superior to the C-grid for the case of both resolved and under-resolved Rossby radius. This is in contrast to the well-known situation for inertia–gravity waves where the B-grid is inferior for the case of resolved Rossby radius.

THE METHOD OF SPACE-TIME CONSERVATION ELEMENT AND SOLUTION ELEMENT—A NEW APPROACH FOR SOLVING THE NAVIER–STOKES AND EULER EQUATIONS. Sin-Chung Chang, *NASA Lewis Research Center, Cleveland, Ohio 44135, U.S.A.*

A new numerical framework for solving conservation laws is being developed. This new framework differs substantially in both concept and methodology from the well-established methods, i.e., finite difference, finite volume, finite element, and spectral methods. It is conceptually simple and designed to overcome several key limitations of the above traditional methods. A two-level scheme for solving the convection-diffusion equation

$$\partial u/\partial t + a\ \partial u/\partial x - \mu\ \partial^2 u/\partial x^2 = 0 \quad (\mu \geq 0)$$

is constructed and used to illuminate major differences between the present method and those mentioned above. This *explicit* scheme, referred to as the a-μ scheme, has two *independent* marching variables u_j^n and $(u_x)_j^n$ which are the numerical analogues of u and $\partial u/\partial x$ at (j, n), respectively. The a-μ scheme has the unusual property that its stability is limited only by the *CFL* condition, i.e., it is independent of μ. Also it can be shown that the amplification factors of the a-μ scheme are identical to those of the Leapfrog scheme if $\mu = 0$, and to those of the DuFort–Frankel scheme if $a = 0$. These coincidences are unexpected because the a-μ scheme and the above classical schemes are derived from completely different perspectives, and the a-μ scheme *does not* reduce to the above classical schemes in the limiting cases. The a-μ scheme is extended to solve the 1D time-dependent Navier–Stokes equations of a perfect gas. Stability of this *explicit* solver also is limited only by the CFL condition. In spite of the fact that it does not use (i) *any* techniques related to the high-

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resolution upwind methods, and (ii) *any* ad hoc parameter, the current *Navier–Stokes* solver is capable of generating highly accurate shock tube solutions. Particularly, for high-Reynolds-number flows, shock discontinuities can be resolved within one mesh interval. The inviscid ($\mu = 0$) a-μ scheme is reversible in time. It also is neutrally stable, i.e., free from numerical dissipation. Such a scheme generally cannot be extended to solve the Euler equations. Thus, the inviscid version is modified. Stability of this modified scheme, referred to as the a-ε scheme, is limited by the CFL condition and $0 \leq \varepsilon \leq 1$, where ε is a special parameter that controls numerical dissipation. Moreover, if $\varepsilon = 0$, the amplification factors of the a-ε scheme are identical to those of the Leapfrog scheme, which has no numerical dissipation. On the other hand, if $\varepsilon = 1$, the two amplification factors of the a-ε scheme become the same function of the Courant number and the phase angle. Unexpectedly, this function also is the amplification factor of the highly diffusive Lax scheme. Note that, because the Lax scheme is very diffusive and it uses a mesh that is staggered in time, a two-level scheme using such a mesh is often associated with a highly diffusive scheme. The a-ε scheme, which also uses a mesh staggering in time, demonstrates that it can also be a scheme with no numerical dissipation. The Euler extension of the a-ε scheme has stability conditions similar to those of the a-ε scheme itself. It has the unusual property that numerical dissipation at all mesh points can be controlled by a set of local parameters. Moreover, it is capable of generating accurate shock tube solutions with the CFL number ranging from close to 1 to 0.022.