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Abstracts of Papers to Appear

A Technique of Treating Negative Weights in WENO Schemes. Jing Shi, Changqing Hu, and Chi-Wang Shu. Division of Applied Mathematics, Brown University, Providence, Rhode Island 02912.

High-order accurate weighted essentially nonoscillatory (WENO) schemes have recently been developed for finite difference and finite volume methods both in structured and in unstructured meshes. A key idea in WENO scheme is a linear combination of lower order fluxes or reconstructions to obtain a higher order approximation. The combination coefficients, also called linear weights, are determined by local geometry of the mesh and order of accuracy and may become negative, such as in the central WENO schemes using staggered meshes, high-order finite volume WENO schemes in two space dimensions, and finite difference WENO approximations for second derivatives. WENO procedures cannot be applied directly to obtain a stable scheme if negative linear weights are present. The previous strategy for handling this difficulty is either by regrouping of stencils or by reducing the order of accuracy to get rid of the negative linear weights. In this paper we present a simple and effective technique for handling negative linear weights without a need to get rid of them. Test cases are shown to illustrate the stability and accuracy of this approach.

Evaluation of the Modified Bessel Function of the Third Kind of Imaginary Orders. Amparo Gil,* Javier Segura,† and Nico M. Temme.‡ *Departamento de Matemáticas. Universidad Autónoma de Madrid, 28049-Madrid, Spain; †Depto. de Matemáticas, Universidad Carlos III de Madrid, 28911-Leganés, Madrid, Spain; and ‡CWI, Postbus 94079, 1090 GB Amsterdam, The Netherlands.

The evaluation of the modified Bessel function of the third kind of purely imaginary order $K_{ia}(x)$ is discussed; we also present analogous results for the derivative. The methods are based on the use of Maclaurin series, nonoscillatory integral representations, asymptotic expansions, and a continued fraction method, depending on the ranges of x and a. We discuss the range of applicability of the different approaches considered and conclude that power series, the continued fraction method, and the nonoscillatory integral representation can be used to accurately compute the function $K_{ia}(x)$ in the range $0 \leq a \leq 200$, $0 \leq x \leq 100$; using a similar scheme the derivative $K'_{ia}(x)$ can also be computed within these ranges.

Methods for the Accurate Computations of Hypersonic Flows. II. Shock-Aligned Grid Technique. Kyu Hong Kim, Chongam Kim, and Oh-Hyun Rho. Department of Aerospace Engineering, Seoul National University, Seoul 151-742, Korea.

In order to eliminate or minimize the numerical error by shock waves due to grid distribution in multidimensional hypersonic flows, a new grid reconstruction scheme, the shock-aligned grid technique (SAGT), is proposed. The error due to shock waves in a non-shock-aligned grid system magnifies in proportion to the Mach number and propagates on the downstream side of the flow field to contaminate sensitive aerodynamic coefficients or flow quantities. SAGT, combined with the AUSMPW+ scheme proposed in Part I of the present work, not only provides an accurate solution but also reduces the grid dependency of a numerical scheme without a substantial increase in computational cost. In addition, SAGT is robust and flexible enough to deal with complex flow problems involving shock interaction and reflection and equilibrium and nonequilibrium effects. Extensive numerical tests from a hypersonic blunt body flow to hypersonic nonequilibrium flows validate the accuracy, efficiency, robustness, and convergence characteristics of SAGT.

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Bounded Skew High-Order Resolution Schemes for the Discrete Ordinates Method. P. J. Coelho. Instituto Superior Técnico, Technical University of Lisbon, Mechanical Engineering Department, Av. Rovisco Pais, 1049-001 Lisbon, Portugal.

The discrete ordinates method for the solution of the radiative heat transfer equation suffers from two main shortcomings, namely ray effects and numerical smearing. Spatial discretization, which is the cause of numerical smearing, constitutes the subject of the present work. Bounded skew high-order resolution schemes are applied to the discrete ordinate equations and compared with standard bounded high-order resolution schemes (CLAM, MUSCL, and SMART), as well as with the step scheme. Calculations are performed for two- and three-dimensional enclosures with transparent, emitting–absorbing, and emitting–absorbing–scattering media. One of the walls of the enclosure is hot, while the others are cold. The results demonstrate that the bounded skew high-order schemes are more accurate than the bounded high-order ones, regardless of the radiative properties of the medium. The improved accuracy is more significant for the radiation intensity along directions oblique to the coordinate lines, but it is also observed for the incident radiation. The difference between the results of the skewed and the standard schemes is attenuated as the optical thickness of the medium increases. A drawback of the skewed schemes is their higher computational requirements, associated with an increased number of iterations required for convergence.

A Hybrid Numerical Asymptotic Method for Scattering Problems. Eldar Giladi* and Joseph B. Keller.† 2124 Rock Street, # 3, Mountain View, California 94043; and †Departments of Mathematics and Mechanical Engineering, Stanford University, Stanford, California 94305.

We develop a hybrid asymptotic numerical method for the Helmholtz equation. The method is a Galerkin finite element method in which the space of trial solutions is spanned by asymptotically derived basis functions. The basis functions are very “efficient” in representing the solution because each is the product of a smooth amplitude and an oscillatory phase factor, as is the asymptotic solution. The phase is determined a priori by solving the eiconal equation using the ray method, while the smooth amplitude is represented by piecewise polynomials. The number of unknowns necessary to achieve a given accuracy with this new basis is dramatically smaller than the number necessary with a standard method, and it is virtually independent of the wavenumber k. We apply the method to the problems of scattering from a parabola and from a circle and compare the results with those of a standard finite element method.