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Abstracts of Papers to Appear

Minimization of the Truncation Error by Grid Adaptation. Nail K. Yamaleev. NASA Langley Research Center, Mail Stop 128, Virginia 23681-2199.

A new grid adaptation strategy, which minimizes the truncation error of a pth-order finite difference approximation, is proposed. The main idea of the method is based on the observation that the global truncation error associated with discretization on nonuniform meshes can be minimized if the interior grid points are redistributed in an optimal sequence. The method does not explicitly require the truncation error estimate, and at the same time, it allows one to increase the design order of approximation globally by one, so that the same finite difference operator reveals superconvergence properties on the optimal grid. Another very important characteristic of the method is that if the differential operator and the metric coefficients are evaluated identically by some hybrid approximation, then the single optimal grid generator can be employed in the entire computational domain independently of points where the hybrid discretization switches from one approximation to another. Generalization of the present method to multiple dimensions is presented. Numerical calculations of several one-dimensional and one two-dimensional test examples demonstrate the performance of the method and corroborate the theoretical results.

Completely Conservative and Oscillationless Semi-Lagrangian Schemes for Advection Transportation. Feng Xiao* and Takashi Yabe.† *Department of Energy Sciences, Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama, 226-8502 Japan; and †Department of Mechanical Engineering and Science, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo, 152-8552 Japan.

In this paper, we present a new type of semi-Lagrangian scheme for advection transportation equation. The interpolation function is based on a cubic polynomial and is constructed under the constraints of conservation of cell-integrated average and the slope modification. The cell-integrated average is defined via the spatial integration of the interpolation function over a single grid cell and is advanced using a flux form. Nonoscillatory interpolation is constructed by choosing proper approximation to the cell-center values of the first derivative of the interpolation function, which appears to be a free parameter in the present formulation. The resulting scheme is exactly conservative regarding the cell average of the advected quantity and does not produce any spurious oscillation. Oscillationless solutions to linear transportation problems were obtained. Incorporated with an entropy-enforcing numerical flux, the presented schemes can accurately compute shocks and sonic rarefaction waves when applied to nonlinear problems.

An Incompressible Three-Dimensional Multiphase Particle-in-Cell Model for Dense Particle Flows. D. M. Snider. Flow Analysis, LLC, 13616 Ernesto Court NE, Albuquerque, New Mexico 87112.

A three-dimensional, incompressible, multiphase particle-in-cell method is presented for dense particle flows. The numerical technique solves the governing equations of the fluid phase using a continuum model and those of the particle phase using a Lagrangian model. Difficulties associated with calculating interparticle interactions for dense particle flows with volume fractions above 5% have been eliminated by mapping particle properties to an Eulerian grid and then mapping back computed stress tensors to particle positions. A subgrid particle, normal stress model for discrete particles which is robust and eliminates the need for an implicit calculation of the particle normal stress on the grid is presented. Interpolation operators and their properties are defined which provide compact support, are conservative, and provide fast solution for a large particle population. The solution scheme allows for distributions of types, sizes, and density of particles, with no numerical diffusion from the Lagrangian

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particle calculations. Particles are implicitly coupled to the fluid phase, and the fluid momentum and pressure equations are implicitly solved, which gives a robust solution.

A New Unconditionally Stable Algorithm for Steady-State Fluid Simulation of High Density Plasma Discharge. Hee-Hwan Choe,* N. S. Yoon,† S. S. Kim,‡ and Duk-In Choi.* *Department of Physics, Korea Advanced Institute of Science and Technology, Taejon 305-701, Korea; †School of Electrical and Electronic Engineering, Chungbuk National University, Chungju Chungbuk 361-763, Korea; and ‡Department of Fundamental Energy Science, Kyoto University, Uji, Kyoto 611-0011, Japan.

A new unconditionally stable algorithm for steady-state fluid simulation of high density plasma discharge is suggested. The physical origin of restriction on simulation time step is discussed and a new method to overcome it is explained. To compare the new method with previous other methods, a one-dimensional fluid simulation of inductively coupled plasma discharge is performed.

Moving Mesh Methods in Multiple Dimensions Based on Harmonic Maps. Ruo Li,* Tao Tang,† and Pingwen Zhang.* *School of Mathematical Sciences, Peking University, Beijing 100871, China; and †Department of Mathematics, The Hong Kong Baptist University, Kowloon Tong, Hong Kong.

In practice, there are three types of adaptive methods using the finite element approach, namely the *h-method*, *p-method*, and *r-method*. In the *h*-method, the overall method contains two parts, a solution algorithm and a mesh selection algorithm. These two parts are independent of each other in the sense that the change of the PDEs will affect the first part only. However, in some of the existing versions of the *r*-method (also known as the *moving mesh method*), these two parts are strongly associated with each other and as a result any change of the PDEs will result in the rewriting of the whole code. In this work, we will propose a *moving mesh method* which also contains two parts, a solution algorithm and a mesh-redistribution algorithm. Our efforts are to keep the advantages of the *r*-method (e.g., keep the number of nodes unchanged) and of the *h*-method (e.g., the two parts in the code are independent). A framework for adaptive meshes based on the Hamilton–Schoen–Yau theory was proposed by Dvinsky. In this work, we will extend Dvinsky's method to provide an efficient solver for the mesh-redistribution algorithm. The key idea is to construct the harmonic map between the physical space and a parameter space by an *iteration* procedure. Each iteration step is to move the mesh *closer* to the harmonic map. This procedure is simple and easy to program and also enables us to keep the map harmonic even after long times of numerical integration.The numerical schemes are applied to a number of test problems in two dimensions. It is observed that the mesh-redistribution strategy based on the harmonic maps adapts the mesh extremely well to the solution without producing skew elements for multi-dimensional computations.