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Abstracts of Papers to Appear

Application of the Difference Gaussian Rules to Solution of Hyperbolic Problems. II. Global Expansion. Sergey Asvadurov,* Vladimir Druskin,* and Leonid Knizhnerman.† *Schlumberger-Doll Research, Old Quarry Road, Ridgefield, Connecticut 06877-4108; and †Central Geophysical Expedition, Narodnogo Opolcheniya St., 40-3, Moscow 123298, Russia.

This work is the sequel to S. Asvadurov *et al.* (2000, *J. Comput. Phys.* **158,** 116), where we considered a grid refinement approach for second-order finite-difference time domain schemes. This approach permits one to compute solutions of certain wave equations with exponential superconvergence. An algorithm was presented that generates a special sequence of grid steps, called "optimal," such that a standard finite-difference discretization that uses this grid produces an accurate approximation to the Neumann-to-Dirichlet map. It was demonstrated that the application of this approach to some problems in, e.g., elastodynamics results in a computational cost that is an order of magnitude lower than that of the standard scheme with equally spaced gridnodes, which produces the same accuracy. The main drawback of the presented approach was that the accurate solution could be obtained only at some a priori selected points (receivers). Here we present an algorithm that, given a solution on the coarse "optimal" grid, accurately reconstructs the solution of the corresponding fine equidistant grid with steps that are approximately equal to the minimal step of the optimal (strongly nonuniform) grid. This "expansion" algorithm is based on postprocessing of the approximate solution, is local in time (but not in space), and has a cost comparable to that of the discrete Fourier transform. An approximate inverse to the "expansion" procedure—the "reduction" algorithm—is also presented. We show different applications of the developed procedures, including refinement of a nonmatching grid. Numerical examples for scalar wave propagation and 2.5D cylindrical elasticity are presented.

A Stable, Perfectly Matched Layer for Linearized Euler Equations in Unsplit Physical Variables. Fang Q. Hu. Department of Mathematics and Statistics, Old Dominion University, Norfolk, Virginia 23529.

The instability of an earlier perfectly matched layer (PML) formulation for the linearized Euler equations is investigated. It is found that, in the presence of a mean flow, there exist acoustic waves that have a positive group velocity but a negative phase velocity in the direction of the mean flow and these waves become actually amplified in the previous formulation, thus giving rise to the instability. A new stable PML formulation that is perfectly matched to the Euler equations and does not entail exponentially growing solution is presented. Furthermore, the new formulation is given in unsplit physical variables which should facilitate its implementation in many practical schemes. In addition, the well-posedness of the new formulation is also considered. It is shown that the proposed equations are well-posed for horizontal y-layers but weakly well-posed for vertical x-layers and corner layers. However, it is further shown that they can be easily modified to be symmetrizable, thus strongly well-posed, by an addition of arbitrarily small terms. Numerical examples that verify the stability and effectiveness of the proposed PML equations, such as an absorbing boundary condition, are given.

A Stochastic Projection Method for Fluid Flow. I. Basic Formulation. Olivier P. Le Maître,* Omar M. Knio,† Habib N. Najm,‡ and Roger G. Ghanem.§ *Centre d'Etudes de Mécanique d'Ile de France, Université d'Evry Val d'Essone, 40, rue du Pelvoux, 91020 Evry Cedex, France; †Department of Mechanical Engineering, The Johns Hopkins University, Baltimore, Maryland 21218-2686; ‡Combustion Research Facility, Sandia National Laboratories, Livermore, California 94550; and §Department of Civil Engineering, The Johns Hopkins University, Baltimore, Maryland 21218-2686.

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We describe the construction and implementation of a stochastic Navier–Stokes solver. The solver combines a spectral stochastic uncertainty representation scheme with a finite difference projection method for flow simulation. The uncertainty quantification scheme is adapted from the spectral stochastic finite element methods (SSFEM), which is based on regarding uncertainty as generating a new dimension and the solution as being dependent on this dimension. In the SSFEM formalism, the stochastic dependence is represented in terms of the polynomial chaos system, and the coefficients in the corresponding spectral representation are obtained using a Galerkin approach. It is shown that incorporation of the spectral uncertainty representation scheme into the projection method results in a coupled system of advection–diffusion equations for the various uncertainty fields, and in a *decoupled* system of pressure projection steps. This leads to a very efficient stochastic solver, whose advantages are illustrated using steady and transient simulations of transport and mixing in a microchannel.

The Treatment of Reacting Surfaces for Finite-Volume Schemes on Unstructured Meshes. Sandip Mazumder and Samuel A. Lowry. CFD Research Corporation, Huntsville, Alabama 35805.

A rigorous and robust numerical procedure to treat surface reaction boundary conditions for finite-volume schemes in unstructured meshes is presented. The procedure is applicable to arbitrary cell topologies and multistep finite-rate surface reactions of arbitrary complexity. The accuracy of the numerical procedure has been verified by systematically comparing solutions obtained using unstructured meshes with perfectly orthogonal meshes for both two-dimensional and three-dimensional geometries. Validation results presented for gallium arsenide growth in a full-scale commercial metal organic-chemical vapor-deposition reactor, exhibit excellent match with experimental data.

Particle Simulation of the Neoclassical Plasmas. J. A. Heikkinen,* T. P. Kiviniemi,† T. Kurki-Suonio,† A. G. Peeters,‡ and S. K. Sipilä.† *VTT Chemical Technology, Euratom-TEKES Association, P.O. Box 1404, FIN-02044 VTT, Finland; †Helsinki University of Technology, Euratom-TEKES Association, FIN-02015 HUT, Finland; and ‡Max-Planck-Institut für Plasmaphysik—EURATOM Association, D-85748 Garching, Germany.

A 5D Monte Carlo particle simulation method for advancing rotating plasmas in tori is presented. The method exploits the neoclassical radial current balance (quasineutrality condition). Including the ion polarization current gives the time rate of change of the radial electric field and related evolution of the rotation velocity components. A special orbit initialization for a quiescent start and an efficient radial flux solving algorithm with reduced numerical noise are developed. Numerical stability of the method with respect to the strength of the perpendicular viscosity and Mach number of the poloidal rotation is investigated. This new approach enables one to separate the nonambipolar transport characteristics from the ambipolar ones. Because nonambipolar transport can support sheared flows, this model can provide a very efficient tool for studying transport barriers and related neoclassical mechanisms in toroidal plasmas.