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Abstracts of Papers to Appear in Future Issues

SPECTRAL SIMULATIONS OF ELECTROMAGNETIC WAVE SCATTERING, B. Yang, D. Gottlieb, and J. S. Hesthaven. *Division of Applied Mathematics, Brown University, Box F, Providence, Rhode Island 02912.*

This paper presents a multidomain pseudospectral method for accurately solving Maxwell's equations in the time domain. The scheme is developed for computing scattering by two-dimensional smooth perfectly conducting objects like circular or elliptic cylinders in free space and utilizes a Fourier collocation method in the azimuthal direction and a multidomain Chebyshev collocation method in the radial direction. Proper absorbing boundary conditions are discussed and a new perfectly matched layer (PML) method in polar coordinates is constructed and shown to be superior to other PML methods. For the elliptic cylinders we propose to use a matched layer in connection with the multidomain approach and a cubic grid mapping. Numerical results of monochromatic electromagnetic scattering by circular and elliptic perfectly electrically conducting cylinders are presented. Comparisons between results obtained using the multidomain pseudospectral method and the finite-difference time domain method clearly illustrate the superiority of spectral methods in obtaining accurate values for the scattered fields and the bistatic radar cross section.

USEFUL BASES FOR PROBLEMS IN NUCLEAR AND PARTICLE PHYSICS. B. D. Keister* and Polyzou.† **Department of Physics, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213; and †Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242.*

A set of exactly computable orthonormal basis functions that are useful in computations involving constituent quarks is presented. These basis functions are distinguished by the property that they fall off algebraically in momentum space and can be exactly Fourier–Bessel transformed. The configuration space functions are associated Laguerre polynomials multiplied by an exponential weight, and their Fourier–Bessel transforms can be expressed in terms of Jacobi polynomials in $\Lambda^2/(k^2 + \Lambda^2)$. A simple model of a meson containing a confined quark–antiquark pair shows that this basis is much better at describing the high-momentum properties of the wave function than the harmonic-oscillator basis.

A HYBRID METHOD FOR MOVING INTERFACE PROBLEMS WITH APPLICATION TO THE HELE–SHAW FLOW. Thomas Y. Hou,* Zhilin Li,† Stanley Osher,† and Hongkai Zhao†. **Applied Mathematics, California Institute of Technology, Pasadena, California 91125; and †Department of Mathematics, University of California at Los Angeles, Los Angeles, California 90095.*

In this paper, a hybrid approach which combines the *immersed interface method* with the *level set approach* is presented. The fast version of the immersed interface method is used to solve the differential equations whose solutions and their derivatives may be discontinuous across the interfaces due to the discontinuity of the coefficients or/and singular sources along the interfaces. The moving interfaces then are updated using the newly developed fast level set formulation which involves computation only inside some small tubes containing the interfaces. This method combines the advantages of the two approaches and gives a second-order Eulerian discretization for interface problems. Several key steps in the implementation are addressed in detail. This new approach is then applied to Hele–Shaw flow, an unstable flow involving two fluids with very different viscosity.

A NOVEL EXPONENTIALLY FITTED TRIANGULAR FINITE ELEMENT METHOD FOR AN ADVECTION–DIFFUSION PROBLEM WITH BOUNDARY LAYERS. Song Wang. *School of Mathematics & Statistics, Curtin University of Technology, GPO Box U1987, Perth 6001, Australia.*

In this paper we develop an exponentially fitted finite element method for a singularly perturbed advection–diffusion problem with a singular perturbation parameter ε. This finite element method is based on a set of novel piecewise exponential basis functions constructed on unstructured triangular meshes. The basis functions cannot be expressed explicitly, but the values of each of them and its associated flux at a point are determined by a set of two-point boundary value problems which can be solved exactly. A method for evaluating elements of the stiffness matrix is also proposed for the case that ε is small. Numerical results, presented to validate the method, show that the method is stable for a large range of ε. It is also shown by the numerical results that the rate of convergence of the method in an energy norm is of order $h^{1/2}$ when ε is small.

A SECOND-ORDER UNSPLIT GODUNOV SCHEME FOR TWO- AND THREE-DIMENSIONAL EULER EQUATIONS. Wenlong Dai and Paul R. Woodward. *University of Minnesota, 116 Church Street S.E., Minneapolis, Minnesota 55455.*

A second-order finite difference scheme is presented in this paper for two- and three-dimensional Euler equations. The scheme is based on nondirectionally split and single-step Eulerian formulations of Godunov approach. A new approach is proposed for constructing effective left and right states of Riemann problems arising from interfaces of one-, two-, and three-dimensional numerical grids. The Riemann problems are solved through an approximate solver in order to calculate a set of time-averaged fluxes needed in the scheme. The scheme is tested through numerical examples involving strong shocks. It is shown that the scheme offers the principle advantages of a second-order Godunov scheme: robust operation in the presence of strong waves and thin shock fronts.

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