Journal of Computational Physics **170,** 917–918 (2001)
doi:10.1006/jcph.2001.6839, available online at http://www.idealibrary.com on IDEAL®

Abstracts of Papers to Appear

A Curvilinear Version of the Bryan–Cox–Semtner Ocean Model and Its Representation of the Arctic Circulation. Ross J. Murray* and C. J. C. Reason.† *School of Earth Sciences, University of Melbourne, Melbourne, Australia; and †EGS and Oceanography Departments, University of Cape Town, South Africa.

Continuous and finite difference forms of the governing equations are derived for a version of the Bryan–Cox–Semtner ocean general circulation model which has been recast in orthogonal, transversely curvilinear coordinates. The coding closely follows the style of the Geophysical Fluid Dynamics Laboratory modular ocean model No. 1. Curvilinear forms are given for the tracer, internal momentum, and stream function calculations, with the options of horizontal and isopycnal diffusion, eddy-induced transport, nonlinear viscosity, and semiimplicit treatment of the Coriolis force. The model is designed to operate on a rectangular three-dimensional array of points and can accommodate reentrant boundary conditions at both 'northern' and 'east–west' boundaries. Horizontal grid locations are taken as input and need to be supplied by a separate grid generation program. The advantages of using a better behaved and more economical grid in the north polar region are investigated by comparing simulations performed on two curvilinear grids with one performed on a latitude–longitude grid and by comparing filtered and unfiltered latitude–longitude simulations. Resolution of horizontally separated currents in Fram Strait emerges as a key challenge for representing exchanges with the Arctic in global models.

Particle-in-Cell Simulation of Electrical Gas Discharges. C. Soria,* F. Pontiga,† and A.Castellanos.* *Dpto. Electrónica y Electromagnetismo Universidad de Sevilla, Av. Reina Mercedes s/n, 41012 Seville, Spain; and †Dpto. Física Aplicada, Universidad de Sevilla, Av. Reina Mercedes s/n, 41012 Seville, Spain.

A fluid particle-in-cell (PIC) model is proposed for the numerical solution of the continuity equation of electrons and ions in transient electrical gas discharges. The reactions occurring in a gaseous discharge, such as ionization of neutral molecules, electron attachment, and recombination between electrons and ions, are implemented through the variation of the mass of the computational particles used in the simulation. Two different forms of interpolation of the gain/loss rates from the grid to the computational particles are suggested, depending on the reaction type. The PIC model is first applied to the problem of an idealized electron avalanche in a non-attaching gas. This problem possesses an analytical solution where the electron density grows exponentially in time as it propagates, but keeps the square-wave form of the initial electron distribution. This problem is used to validate the optimum interpolation of the gain/loss rate and to analyze the effect of the mass-matrix formulation of the PIC model. Then, a more realistic model is applied to simulate the propagation of a Trichel pulse between a sphere and a plate. In this case, the continuity equation for electrons and positive and negative ions, coupled to the Poisson equation, has been solved. This second test has proved the ability of the present numerical method to deal with those discharges dominated by the space charge effect. The results of the PIC simulation are compared with those obtained from the application of a flux-corrected transport method.

A Posteriori Finite-Element Output Bounds for the Incompressible Navier–Stokes Equations: Application to a Natural Convection Problem. L. Machiels,* J. Peraire,† and A. T. Patera.* *Department of Mechanical Engineering; and †Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139.

We present a new Neumann subproblem *a posteriori* finite-element procedure for the efficient calculation of rigorous, constant-free, sharp lower and upper bounds for linear and nonlinear functional outputs of the

incompressible Navier–Stokes equations. We first formulate the bound procedure; we derive and discuss a bound error expression; and we then demonstrate the capabilities of the method with numerical results obtained for natural convection problems. We also implement an optimal adaptive refinement strategy based on a local elemental decomposition of the bound gap.

A High-Order Fast Direct Solver for Singular Poisson Equations. Yu Zhuang[*,†] and Xian-He Sun.[*,‡] [*]Computer Science Department, Louisiana State University, Baton Rouge, Louisiana 70803; [†]Department of Mathematics, Louisiana State University, Baton Rouge, Louisiana 70803; and [‡]Department of Computer Science, Illinois Institute of Technology, Chicago, Illinois 60616.

We present a fourth order numerical solution method for the singular Neumann boundary problem of Poisson equations. Such problems arise in the solution process of incompressible Navier–Stokes equations and in the time-harmonic wave propagation in the frequence space with the zero wavenumber. The equation is first discretized with a fourth order modified Collatz difference scheme, producing a singular discrete equation. Then an efficient singular value decomposition (SVD) method modified from a fast Poisson solver is employed to project the discrete singular equation into the orthogonal complement of the null space of the singular matrix. In the complement of the null space, the projected equation is uniquely solvable and its solution is proven to be a solution of the original singular discrete equation when the original equation has a solution. Analytical and experimental results show that this newly proposed singular equation solver is efficient while retaining the accuracy of the high order discretization.

An Energy-Preserving MAC–Yee Scheme for the Incompressible MHD Equation. Jian-Guo Liu[*] and Wei-Cheng Wang.[†] [*]Institute for Physical Science and Technology and Department of Mathematics, University of Maryland, College Park, Maryland 20742; and [†]Department of Mathematics, National Tsing Hua University.

We propose a simple and efficient finite-difference method for the incompressible MHD equation. The numerical method combines the advantage of the MAC scheme for the Navier–Stokes equation and Yee's scheme for the Maxwell equation. In particular, the semi-discrete version of our scheme introduces no numerical dissipation and preserves the energy identity exactly.