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Abstracts of Papers to Appear

ACCURATE NAVIER–STOKES INVESTIGATION OF TRANSITIONAL AND TURBULENT FLOWS IN A CIRCULAR PIPE.
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A new, fast, accurate, and roundoff-error robust numerical technique for integrating unsteady incompressible Navier–Stokes equations in cylindrical coordinates is presented. The algorithm is based on a special change of dependent variables which avoids the singularity problem and provides high accuracy and computational efficiency. Accuracy and stability of the method are thoroughly tested for the model problem of transitional and turbulent flows in an infinite circular pipe. Verification of the algorithm includes two issues. First, spectral characteristics of the Hagen–Poiseuille flow stability problem are compared with those of the discrete linearized Navier–Stokes operator. Second, the results of direct Navier–Stokes simulation of all stages of laminar-turbulent transition in a circular pipe at Reynolds number of 4000 are presented. Time evolution of finite-amplitude disturbances of laminar flow was calculated until the statistically stationary turbulent flow regime was established. In addition to common statistical analysis, the possibility of turbulence description by means of velocity fields having certain symmetries is examined. Thus, the algorithm presented seems to be a ready-to-use robust tool for accurate investigation and further parametric studies of both transition mechanisms and fully developed turbulent flow regimes.

A SIMPLE FINITE DIFFERENCE SCHEME FOR MULTIDIMENSIONAL MAGNETOHYDRODYNAMICAL EQUATIONS.
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An approximate MHD Riemann solver, an approach to maintain the divergence-free condition of magnetic field, and a finite difference scheme for multidimensional magnetohydrodynamical (MHD) equations are proposed in this paper. The approximate MHD Riemann solver is based on characteristic formulations. Both the conservation laws for mass, momentum, energy, and magnetic field, and the divergence-free condition of the magnetic field are exactly satisfied in the proposed scheme. The scheme does not involve any Poisson solver and is second-order accurate in both space and time. The correctness and robustness of the scheme are shown through numerical examples. The approach proposed in this paper to maintain the divergence-free condition may be applied to other dimensionally split and unsplit Godunov schemes for MHD flows.

A FOURIER–HERMITE PSEUDOSPECTRAL METHOD FOR PENETRATIVE CONVECTION.
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A Fourier–Hermite pseudospectral method is developed to study numerically the three-dimensional penetrative convection problem under the Boussinesq approximation. An S-shaped temperature profile in the absence of motion is prescribed in the vertical direction. All variables are expanded in terms of Fourier–Hermite basis functions. The Hermite functions are scaled to adjust the length of the computational domain in the vertical. A semi-implicit scheme is used for time marching with the third-order Adam–Bashforth and Crank–Nicholson schemes for the nonlinear and linear terms, respectively. An implementation of the numerical method on a parallel computer is also described. Numerical simulation results of resolution 64^3 are presented for low-to-moderate Rayleigh numbers with a Prandtl number of unity. The highly stable outer regions are seen to act as effective lids and all penetrative

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flow are contained within the computational box. Variances, heat fluxes, and their budgets are reported for several Rayleigh numbers to demonstrate the efficacy of the numerical method.

AN IMPROVED CONVECTION SCHEME APPLIED TO RECOMBINING DIVERTOR PLASMA FLOWS. D. A. Knoll. *Applied Theoretical and Computational Physics Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.* E-mail: nol@lanl.gov.

A high-order finite volume convection scheme, in conjunction with a monotonicity-preserving flux-limiter is applied to a combined tokamak edge plasma/Navier–Stokes neutral transport model. This is a highly nonlinear system of convection–diffusion–reaction equations which describe the partially ionized boundary layer plasma of a tokamak fusion reactor. The solutions of interest contain a sharp ionization front. The improved convective discretization is applied within the context of the existing matrix-free Newton–Krylov solution algorithm. More accurate convective differencing is shown to make a significant difference on a problem of current interest. It is demonstrated that a matrix-free Newton–Krylov implementation, where the preconditioner is derived using first-order upwind convective differencing, provides savings in both memory requirements and CPU time.