pair of two finite-core regions; (2) a boundary value problem for the unsteady flow field around a rotating cylinder with high Reynolds number up to $Re_d = U \cdot D/\nu = 10{,}000$. Numerical results are compared with either exact solutions or other numerical methods. The numerical advantages of the diffusing-vortex scheme over other conventional vortex methods, cloud-in-cell methods, particle methods, and some finite difference schemes are evaluated in terms of reducing total CPU time, avoiding cutoff procedures and sidestepping various interpolations.

SPECTRAL COLLOCATION METHODS AND POLAR COORDINATE SINGULARITIES. Henner Eisen, Wilhelm Heinrichs, and Kristian Witsch, *Heinrich-Heine-Universität Düsseldorf, Lehrstuhl für Angewandte Mathematik, Düsseldorf, WEST GERMANY (FRG).*

This paper considers the numerical solution of elliptic differential equations on the unit disk. Using polar coordinates, the disk is mapped onto a rectangle. The resulting transformed problem is solved by a method related to collocation. Since the origin is a coordinate singularity, some natural trial functions are singular there and a special technique is applied to use zero as a collocation point. For Poisson and Helmholtz equations, a fast algorithm with an operation count of $\mathcal{O}(N^2 \log N)$ is presented. Numerical results show the different stability and convergence properties of the algorithms.

A NUMERICAL SCHEME FOR THE SOLUTION OF THE SPACE CHARGE PROBLEM ON A MULTIPLY CONNECTED REGION. C. J. Budd, *Oxford University Computing Laboratory, Oxford, UNITED KINGDOM*; A. A. Wheeler, *School of Mathematics, Bristol, UNITED KINGDOM.*

In this paper we extend the work of Budd and Wheeler, who described a new numerical scheme for the solution of the space charge equation on a simply connected domain, to multiply connected regions. The space charge equation, $\nabla \cdot (\Delta\bar{\varphi}\nabla\bar{\varphi}) = 0$, is a third-order nonlinear partial differential equation for the electric potential $\bar{\varphi}$, which models the electric field in the vicinity of a coronating conductor. Budd and Wheeler described a new way of analysing this equation by constructing an orthogonal coordinate system $(\bar{\varphi}, \bar{\psi})$ and recasting the equation in terms of x, y and $\Delta\bar{\varphi}$ as functions of $(\bar{\varphi}, \bar{\psi})$. This transformation is singular on multiply connected regions and in this paper we show how this may be overcome to provide an efficient numerical scheme for the solution of the space charge equation. This scheme also provides a new method for the solution of Laplaces equation and the calculation of orthogonal meshes on multiply connected regions.

DIRECT SIMULATIONS OF TURBULENT FLOW USING FINITE-DIFFERENCE SCHEMES. Man Mohan Rai, *NASA Ames Research Center, Moffett Field, California, USA*; Parvis Moin, *Stanford University, Stanford, California and NASA Ames Research Center, Moffett Field, California, USA.*

This paper presents finite-difference solutions to the evolution of small-amplitude disturbances and incompressible fully developed turbulent channel flow. The main objective of the paper is to provide a comprehensive comparison between the results obtained using finite-difference and spectral methods. An advantage of finite-difference schemes over the highly accurate spectral methods lies in the ease with which they can be applied to complex geometries. The finite-difference methods used include a kinetic-energy-conserving type of central difference scheme and a high-order-accurate upwind difference scheme. Unlike the central difference scheme, the upwind difference scheme was found not to require a kinetic energy conservation property to control aliasing error. The dissipative nature of the upwind scheme results in a damping of the higher frequency content. As a result very little energy is aliased back. The computed data (including first- and second-order statistics) for the turbulent channel flow case are found to compare well with experimental data and earlier spectral simulations. It appears that the high-order-accurate upwind scheme is a good candidate for direct simulations of turbulent flows over complex geometries.