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Abstracts of Papers to Appear in Future Issues

A NON-STAGGERED GRID, FRACTIONAL STEP METHOD FOR TIME-DEPENDENT INCOMPRESSIBLE NAVIER–STOKES EQUATIONS IN CURVILINEAR COORDINATES. Yan Zang, Robert L. Street, and Jeffrey R. Koseff. *Environmental Fluid Mechanics Laboratory, Stanford University, California 94305-4020, U.S.A.*

A numerical method for solving three-dimensional, time-dependent incompressible Navier–Stokes equations in curvilinear coordinates is presented. The non-staggered-grid method originally developed by C. M. Rhie and W. L. Chow (*AIAA J.* **21**, 1525 (1983)) for steady state problems is extended to compute unsteady flows. In the computational space, the Cartesian velocity components and the pressure are defined at the center of a control volume, while the volume fluxes are defined at the mid-point on their corresponding cell faces. The momentum equations are integrated semi-implicitly by the approximate factorization technique. The intermediate velocities are interpolated onto the faces of the control volume to form the source terms of the pressure Poisson equation, which is solved iteratively with a multigrid method. The compatibility condition of the pressure Poisson equation is satisfied in the same manner as in a staggered-grid method; mass conservation can be satisfied to machine accuracy. The pressure boundary condition is derived from the momentum equations. Solutions of both steady and unsteady problems including the large eddy simulation of a rotating and stratified upwelling flow in an irregular container established the favorable accuracy and efficiency of the present method.

IMPROVED CONVERGENCE TO THE STEADY STATE OF THE EULER EQUATIONS BY ENHANCED WAVE PROPAGATION. Per Lötstedt. *Department of Scientific Computing, Uppsala University, Uppsala, Sweden and SAAB-SCANIA, Linköping, Sweden.*

The convergence to the numerical solution of the stationary Euler equations in two and three dimensions is studied. The basic iterative algorithms are Runge–Kutta time-stepping, GMRES, and a modified GMRES method. Convergence acceleration is achieved by two preconditioning techniques: residual smoothing and multigrid iteration. The preconditioners are such that they increase the propagation of smooth error modes out of the computational domain. Runge–Kutta time-stepping and the modified GMRES method guarantee this wave propagation. The results from a number of numerical experiments are reported

ELLIPTICITY, ACCURACY, AND CONVERGENCE OF THE DISCRETE NAVIER–STOKES EQUATIONS. S. W. Armfield. *Department of Civil and Environmental Engineering, University of Western Australia, Perth, Western Australia 6009, Australia.*

The introduction into the continuity equation of additional terms to recover grid-scale ellipticity, for the Navier–Stokes equations discretised on a non-staggered mesh, results in an increase in the discretisation error. The introduced error is a combination of the additional truncation error and a false source resulting from the inconsistent construction of the conservation equations used in the finite volume scheme considered. The false source error component is removed by constructing the conservation terms consistently, while the additional truncation error is shown to be of the same order as the leading order truncation error associated with the unmodified equations. A method of reducing the magnitude of the additional terms, thereby reducing the additional error, is considered. It is shown that although this does reduce the magnitude of the error it also reduces the ellipticity of the equations and leads to slower convergence.

ON ESSENTIALLY NON-OSCILLATORY SCHEMES ON UNSTRUCTURED MESHES: ANALYSIS AND IMPLEMENTATION. R. Abgrall. *INRIA, BP 93, 06902 Sophia Antipolis Cedex, France.*

During the past few years, the class of essentially non-oscillatory schemes for the numerical simulation of hyperbolic equations and systems has been constructed. Since then, a few extensions have been made to multidimensional simulations of compressible flows, mainly in the context of very regular structured meshes. In this paper, we first recall and improve the results of an earlier paper about non-oscillatory reconstruction on unstructured meshes. We put much emphasis on the effective calculation of the reconstruction. Then, we describe a class of numerical schemes on unstructured meshes. We give some applications for its third order version. They demonstrate that a higher order of accuracy is indeed obtained, even on very irregular meshes.

HIGH ORDER DIFFERENCE SCHEMES FOR UNSTEADY ONE-DIMENSIONAL DIFFUSION–CONVECTION PROBLEMS. Alain Rigal. *Laboratoire d'Analyse Numérique, 118, route de Narbonne, 31062 Toulouse Cedex, France.*

For unsteady 1D diffusion–convection problems, this paper develops an extensive analysis of two-level three-point finite difference schemes of order 2 in time and 4 in space. This general class of FDS includes several schemes independently proposed by different authors. One main objective is the identification of difference schemes yielding satisfactory numerical results for strongly convective problems (i.e., when the cell Reynolds number $\alpha = \lambda h/2$ is greater than unity). The stability and the oscillatory behaviour of the schemes are carefully studied and the analyses are completed by some numerical experiments. We outline some key points: (i) the great difficulty to obtain accurate numerical results for large values of α; (ii) the possibility of virtually optimum schemes is essentially theoretical and requires, in practice, careful experiments; (iii) for strongly convective problems, some second-order explicity schemes are almost as efficient (and less costly) than implicit fourth-order schemes.

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