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Abstracts of Papers to Appear in Future Issues

PRECONDITIONED MULTIGRID METHODS FOR COMPRESSIBLE FLOW CALCULATIONS ON STRETCHED MESHES. Niles A. Pierce and Michael B. Giles. *Oxford University Computing Laboratory, Numerical Analysis Group, Oxford OX1 3QD, United Kingdom.*

Efficient preconditioned multigrid methods are developed for both inviscid and viscous flow applications. The work is motivated by the mixed results obtained using the standard approach of scalar preconditioning and full coarsened multigrid, which performs well for Euler calculations on moderately stretched meshes but is far less effective for turbulent Navier–Stokes calculations, when the cell stretching becomes severe. In the inviscid case, numerical studies of the preconditioned Fourier footprints demonstrate that a block–Jacobi matrix preconditioner substantially improves the damping and propagative efficiency of Runge–Kutta time-stepping schemes for use with full coarsened multigrid, yielding computational savings of approximately a factor of three over the standard approach. In the viscous case, determination of the analytic expressions for the preconditioned Fourier footprints in an asymptotically stretched boundary layer cell reveals that all error modes can be effectively damped using a combination of block–Jacobi preconditioning and a J-coarsened multigrid strategy, in which coarsening is performed only in the direction normal to the wall. The computational savings using this new approach are roughly a factor of 10 for turbulent Navier–Stokes calculations on highly stretched meshes.

A RIEMANN PROBLEM BASED METHOD FOR THE RESOLUTION OF COMPRESSIBLE MULTIMATERIAL FLOWS. Jean-Pierre Cocchi and Richard Saurel. *Institut Universitaire des Systèmes Thermiques Industriels, CNRS-UMR 6595, 5 rue Enrico Fermi, 13453 Marseille Cedex 13, France.*

A correction for Godunov-type methods is described, yielding a perfect capture of contact discontinuities, in hydrodynamic flow regime. The correction is based upon a simple idea: starting from a nondegraded solution at a given instant, the use of an Eulerian scheme around a contact discontinuity will entail, at the next instant, the degradation of the solution at only the two adjacent nodes to the discontinuity. The exact solution of the Riemann problem yields the state variables on both sides of the discontinuity. Knowledge of these variables may be used to correct the two nodes affected by numerical diffusion. The method is applied to problems involving a gas–liquid interface. The liquid is assumed compressible, obeying the "stiffened gas" equation of state, for which the solution of the Riemann problem is easily obtained. The method is first tested with 1D problems which have either an exact solution or accurate numerical solutions in the literature. Then the concept is extended in two dimensions. Assuming that the 1D Riemann problem along the normal to the interface is a reasonable approximation of the 2D Riemann problem for Euler equations, we extend efficiently the algorithm for two-dimensional interface problems. Several two-dimensional test cases are presented for which the method provides accurate solutions.

MULTIGRID COMPUTATION OF STRATIFIED FLOW OVER TWO-DIMENSIONAL OBSTACLES. M. F. Paisley. *Department of Mathematics and Statistics, School of Computing, Staffordshire University, Stafford, ST18 0AD United Kingdom.*

A robust multigrid method for the incompressible Navier–Stokes equations is presented and applied to the computation of viscous flow over obstacles in a bounded domain under conditions of neutral stability and stable density stratification. Two obstacle shapes have been used, namely a vertical barrier, for which the grid is Cartesian, and a smooth cosine-shaped obstacle, for which a boundary-conforming transformation is incorporated. Results are given for laminar flows at low Reynolds numbers and turbulent flows at a high Reynolds number, when a simple mixing length turbulence model is included. The multigrid algorithm is used to compute steady flows for each obstacle at low and high Reynolds numbers in conditions of weak static stability, defined by $K = ND/\pi U \leq 1$, where U, N, and D are the upstream velocity, bouyancy frequency, and domain height, respectively. Results are also presented for the vertical barrier at low and high Reynolds number in conditions of strong static stability, $K > 1$, when lee wave motions ensure that the flow is unsteady, and the multigrid algorithm is used to compute the flow at each timestep.

CELL ASPECT RATIO DEPENDENCE OF ANISOTROPY MEASURES FOR RESOLVED AND SUBGRID SCALE STRESSES. Hans-Jakob Kaltenbach. *Department 3, Mathematics, MA 6-3, Technical University Berlin, 10623 Berlin, Germany.*

Discrete approximation of a flow field using anisotropic meshes causes "unphysical" anisotropy of the resolved part of the Reynolds stress tensor and of the subgrid scale stress tensor if common anisotropy measures such as $\overline{u_i u_j}/q^2 - 1/3\delta_{ij}$ are used in order to characterize the turbulence structure. By evaluating model spectrum tensors the effect is investigated for isotropic and anisotropic turbulence. The deviation from a physical meaningful anisotropy state depends on various parameters such as the energy spectrum shape near the cutoff in wavespace, the cell aspect ratios, and the range of scales which are resolved. Subgrid kinetic energy must be distributed unequally among the normal stresses on an anisotropic mesh. For example, for aspect ratios $\Delta x : \Delta y : \Delta z = 1:8:4$ rms fluctuations of subgrid motions are shown to deviate by 9% in isotropic turbulence in the inertial subrange.

A VARIATIONAL FORM OF THE WINSLOW GRID GENERATOR. A. A. Charakhch'yan and S. A. Ivanenko. *Computing Center of the Russian Academy of Sciences, Vavilov Str. 40, Moscow GSP-1, 117967 Russia.*

A structured grid generator based on a new approximation of Dirichlet's functional is developed. An unconstrained minimization process guarantees that all quadrilateral grid cells are convex at each iteration. Numerical results are presented in comparison with those for the original form of the Winslow method. A generalization to the case of adaptive grids based on harmonic maps between surfaces is considered.

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