

# Numerical Methods for the Navier-Stokes Equations

Proceedings of the International Workshop  
held at Heidelberg, October 25–28, 1993

Edited by  
Friedrich-Karl Hebeker,  
Rolf Rannacher and  
Gabriel Wittum



# CONTENTS

|                                                                                                                                                                                                                     | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| M. BERZINS, J. M. WARE: <i>Reliable Finite Volume Methods for Navier-Stokes Equations</i> .....                                                                                                                     | 1    |
| S. BIKKER, H. GREZA, W. KOSCHEL: <i>Parallel Computing and Multigrid Solution on Adaptive Unstructured Meshes</i> .....                                                                                             | 9    |
| X.-C. CAI, W. D. GROPP, D. E. KEYES, M. D. TIDRIRI: <i>Newton-Krylov-Schwarz Methods in CFD</i> .....                                                                                                               | 17   |
| H. DANIELS, A. PETERS: <i>PASTIS-3D - A Parallel Finite Element Projection Code for the Time-Dependent Incompressible Navier-Stokes Equations</i> .....                                                             | 31   |
| E. DICK, J. STEELANT: <i>Coupled Solution of the Steady Compressible Navier-Stokes Equations and the <math>k</math>-<math>\epsilon</math>-Turbulence Equations with a Relaxation Method</i> .....                   | 40   |
| O. DOROK, W. GRAMBOW, L. TOBISKA: <i>Aspects of Finite Element Discretizations for Solving the Boussinesq Approximation of the Navier-Stokes Equations</i> ....                                                     | 50   |
| D. DRIKAKIS, F. DURST: <i>Study of Extended Flow Separation on Parallel Machines</i>                                                                                                                                | 62   |
| M. FEISTAUER, P. KNOBLOCH: <i>Operator Splitting Method for Compressible Euler and Navier-Stokes Equations</i> .....                                                                                                | 70   |
| J. FONTAINE, TA PHUOC LOC: <i>An Efficient Numerical Algorithm for Velocity Vorticity 3D Unsteady Navier-Stokes Equations: Application to the Study of a Separated Flow Around a Finite Rectangular Plate</i> ..... | 79   |
| L. P. FRANCA: <i>Incompressible Flows Based upon Stabilized Methods</i> .....                                                                                                                                       | 89   |
| V. HANNEMANN, D. HEMPEL, T. SONAR: <i>Adaptive Computation of Compressible Flow Fields with the DLR-<math>\tau</math>-Code</i> .....                                                                                | 101  |
| W. HEINRICHS: <i>Defect Correction for Convection Dominated Flow</i> .....                                                                                                                                          | 111  |
| A. HUJEIRAT, R. RANNACHER: <i>An Operator Splitting Approach for Computing Compressible Flows in Astrophysics</i> .....                                                                                             | 121  |
| C. JOHNSON, R. RANNACHER: <i>On Error Control in CFD</i> .....                                                                                                                                                      | 133  |
| Y. KALLINDERIS: <i>Parallel Grid Adaption</i> .....                                                                                                                                                                 | 145  |

# CONTENTS (continued)

|                                                                                                                                                                             | Page |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| M. KURRECK, R. KOCH, S. WITTIG: <i>Numerical Simulation of Turbulent Three-Dimensional Flow Problems on Parallel Computing Systems</i> .....                                | 157  |
| P. R. M. LYRA, K. MORGAN, J. PERAIRE: <i>A High-Resolution Flux Splitting Scheme for the Solution of the Compressible Navier-Stokes Equations on Triangular Grids</i> ..... | 167  |
| C.-D. MUNZ, R. SCHNEIDER, O. GERLINGER: <i>The Numerical Approximation of a Free Gas-Vacuum Surface</i> .....                                                               | 181  |
| H. NIRSCHL, H. A. DWYER, V. DENK: <i>A Chimera Grid Scheme for the Calculation of the Flow Around Particles in Difficult Geometries</i> .....                               | 191  |
| A. PINELLI, A. VACCA: <i>A New Multi-Domain Algorithm for the Spectral Solution of the Incompressible Navier-Stokes Equations</i> .....                                     | 199  |
| H. REICHERT, G. WITTUM: <i>On the Construction of Robust Smoothers for Incompressible Flow Problems</i> .....                                                               | 207  |
| H.- G. ROOS, D. ADAM, A. FELGENHAUER: <i>A Nonconforming Uniformly Convergent Finite Element Method in Two Dimensions</i> .....                                             | 217  |
| M. SCHÄFER, E. SCHRECK, K. WECHSLER: <i>An Efficient Parallel Solution Technique for the Incompressible Navier-Stokes Equations</i> .....                                   | 228  |
| K. SCHENK, F. K. HEBEKER: <i>Coupling of Two Dimensional Viscous and Inviscid Incompressible Stokes Equations</i> .....                                                     | 239  |
| F. SCHIEWECK: <i>On the Order of Two Nonconforming Finite Element Approximations of Upwind Type for the Navier-Stokes Equations</i> .....                                   | 249  |
| E. SCHÖLL, H.- H. FRÜHAUF: <i>An Accurate and Efficient Implicit Upwind Solver for the Navier-Stokes Equations</i> .....                                                    | 259  |
| P. SCHREIBER, S. TUREK: <i>An Efficient Finite Element Solver for the Nonstationary Incompressible Navier-Stokes Equations in Two and Three Dimensions</i> .....            | 268  |
| C. TENAUD, TA PHUOC LOC: <i>Numerical Simulation of Unsteady Compressible Viscous Flow Around NACA 0012 Airfoil</i> .....                                                   | 278  |
| R. VERFÜRTH: <i>A Posteriori Error Estimates for Non-Linear Problems</i> .....                                                                                              | 288  |
| P. WESSELING, C. G. M. KASSELS, C. W. OOSTERLEE, A. SEGAL, C. VUIK, S. ZENG, M. ZIJLEMA: <i>Computing Incompressible Flows in General Domains</i> ...                       | 298  |