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Book Review

Turbulence and Transition Modeling

M. Hallback, D. S. Henningson, A. V. Johansson, and P. H. Alfredsson (Eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1996, 368 pp., $148.00

This book is the result of a series of lectures given at the ERCOFTAC/IUTAM Summerschool held in Stockholm in June 1995. Its purpose is to introduce students, engineers, and researchers to turbulence modeling and transition prediction methods, to provide a physical background in these fields, and to indicate some advanced uses of the methods. It is unique in the sense that it is the only book that combines the subjects of turbulence and transition into a single volume. It is clear that it will become a standard reference on the subject. The lectures were given by accomplished experts in their fields, and the editors have done an excellent job in integrating the different lectures into a coherent whole.

To keep the book within reasonable bounds, the coverage has been restricted primarily to incompressible flows; the effects of compressibility, buoyancy, chemical reactions, etc., are not discussed. This omission does not, however, detract from the overall importance and value of the work.

After a brief introduction by the editors, the book opens with a chapter on stability and transition by D. S. Henningson and P. H. Alfredsson in which the classical stability theory of channel and boundary-layer flows is given with applications to the prediction of transition in several practical cases. The discussion includes descriptions of inviscid and viscous stability analyses and the stability of complex boundary layers, including the effects of curvature and rotation and three-dimensionality. The physical aspects of instability and breakdown are very well described. The discussion of transition includes such topics as receptivity, bypass transition, transition emanating from exponential instabilities (e.g., Tollmein–Schlichting waves), and the modeling of transition using the e^n approach.

The basics of turbulence modeling is the subject of the third chapter, by M. Hallback, A. V. Johansson, and A. D. Burden. The chapter emphasizes the more current and advanced aspects of the subject. The hierarchy of single-point closures from simple eddy viscosity models to Reynolds stress models is discussed. The various conditions that a closure should satisfy, such as coordinate and material frame indifference, invariant modeling, realizability, and near wall asymptotics, are discussed. Excellent and detailed descriptions of Reynolds stress and algebraic stress models are given, although only a cursory survey of the simpler zero-, one-, and two-equation models is included. Near wall treatments and model development tools such as direct numerical simulation (DNS) and rapid distortion theory are also covered.

Chapter 4, written by T. H. Shih, describes the development of constitutive relations and realizability conditions for single-point closures. This chapter goes into more detail than the preceding chapter in describing the development of constitutive relations and realizability conditions for the various correlations appearing in single-point closures. A section on the application of realizability to second-order closures is included, and detailed descriptions and applications of various models are also given.

"Advanced Turbulence Models for Industrial Application" is the title of Chapter 5, by B. E. Launder, in which the recent modeling activity at the University of Manchester is described. The development includes nonlinear eddy viscosity or explicit algebraic stress models (EASM) as well as Reynolds stress transport models. The development of EASM emphasizes a newly developed three-equation model. Applications include homogeneous flows, two- and three-dimensional channel and duct flows, impinging jets, various self-similar free shear layers, a curved channel, and bypass transition on a flat plate.

"One-Point Closures Applied to Transition" is the title of Chapter 6, by A. M. Savill. This gives an excellent review of the status of bypass transition modeling using eddy viscosity and Reynolds stress transport models. Also included is a brief discussion of integral and intermittency methods applied to transition prediction. Calculations using various models are compared with both experiment and DNS and large eddy simulation (LES) results. Applications include zero and variable pressure gradient boundary layers and blunt body and turbine blade flows.

"Large-Eddy Simulations: Theory and Practice" is the title of Chapter 7, by U. Piomelli and J. R. Chasnov. It summarizes the current status of LES research with respect to the prediction of turbulent and transitional flows. The development includes descriptions of the basic governing equations and filters and the principles of small-scale and subgrid-scale modeling and numerical methods. Applications described include homogeneous and wall-bounded turbulent flows, transitional and relaminarizing flows, and separated and highly three-dimensional flows.

The concluding chapter, by F. P. Bertolotti, covering transition modeling based on the parabolized stability equations (PSE), describes the current state of the art in stability and transition predictions based on the PSE. Following a brief introduction comparing the PSE approach to other approaches for stability calculations, the basic theory of the linear PSE is developed. This is followed by a description of discretization methods and initial and boundary conditions and then a discussion of nonlinear formulations. Receptivity, including the effects of sound, surface undulations, and vortical freestream disturbances, is then discussed.

In summary, the editors and authors are to be congratulated for producing an excellent text that will become a basic reference in the fields of turbulence and transition modeling and research.

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