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Book Reviews

Turbulence Structure and Vortex Dynamics

Edited by J. C. R. Hunt and J. C. Vassilicos, Cambridge University Press, New York, 2000, 306 pp., $80.00

This is one of the most recent volumes resulting from the half-year-long program on turbulence held at Cambridge University's Isaac Newton Institute of Mathematical Sciences in the first half of 1999. The workshops, conferences, and symposia held as part of the program and attended by physicists, engineers, mathematicians, and fluids experimentalists have already led to review papers and volumes, published by Cambridge or Kluwer, on intermittency in turbulent flows, closure strategies for turbulent and transitional flows, and large-eddy simulations. The immediate volume, bearing the same title as a symposium held as part of the program, reflects the central role vortex structure and dynamics have come to play in modern turbulence theory and experiment. The writers of the 15 separate papers in the book include some of the leading theoreticians and experimentalists in turbulence research. Although some of the papers give useful background material, they are probably too demanding to be useful or accessible to the general reader. But such a reader accepting the challenge will come away with a good feel for some of the most fruitful avenues currently being pursued by the leading researchers, and the specialist will be grateful for a single volume providing both a snapshot of where research stood near the end of the past century and a blueprint for the first decade of the new one. The reader will find all of the usual words and phrases to be expected in a volume exploring vorticity and turbulence: vortex stretching and compression, vortex instabilities, vortex packets, strain, dissipation, coherent structures, system rotation, etc. The reader cannot help but come away with an enormous respect for the variety of vortex structures that arise in turbulent flows, the complexity of their short- and long range-interactions with other vortices and parts of the flow, and the elegant theories—complex and diverse as the subject they describe—and analytical tools that researchers have devised and developed to tackle these issues.

The papers differ considerably in length, a few being more like extended abstracts, the longest 50 pages, the majority 20–30 pages long. The longer ones, for example the paper by Hunt on the dynamics and statistics of vortical eddies in turbulence, tackle broad issues and are exemplary minitreatises on their subjects, relatively brief but comprehensive. Even the shorter papers have good reference lists. The editors deserve credit for providing, in their Introduction, succinct comments about each of the papers, showing their connections or describing how they tackle the same or related problems from different points of view.

The production of the book is up to the high standards we customarily expect of Cambridge University Press. The uniform layout of the papers stands in contrast to that of many similar collections. The Isaac Newton Institute, the organizers of the program on turbulence, the editors of this volume, the contributors, and the publisher all deserve our gratitude for providing the setting for the presentation of this work and for so rapidly and attractively disseminating it to the research community.

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Turbulent Flows

Stephen B. Pope, Cambridge University Press, New York, 2000, 771 pages, $49.95

Turbulence has been a challenge from both research and pedagogical viewpoints. The pedagogical difficulties have stemmed from the lack of a comprehensive textbook that covers all of the essential aspects of teaching turbulence, namely, scaling arguments and order-of-magnitude analysis, statistical theory, classical and modern treatments, and computational approaches. In this context, Pope's book represents the outstanding contribution to the pedagogy of turbulence since Tennekes and Lumley's book, *A First Course in Turbulence*, nearly 30 years ago. It combines classical treatment of turbulence with modern approaches based on direct numerical simulations (DNS), probability density functions (PDF), and large eddy simulations (LES). Not only does it present turbulence fundamentals in a lucid and readable manner, it also utilizes in an optimum manner various tools of learning and teaching turbulence: physical insight, mathematical derivations, scaling arguments, and experimental and DNS data.

The book consists of 13 chapters organized into two parts, 10 appendices, and an extensive bibliography at the end. Part I, which contains the first seven chapters, provides a general introduction to turbulent flows, their quantitative and statistical description, classical treatment of turbulence, scales of turbulent motions, and the Reynolds-averaged governing equations. Chapters 5 and 7 of Part I cover free shear and wall-bounded flows, respectively. Part II covers various modeling approaches for simulating and analyzing turbulent flows. These include DNS approaches, turbulent viscosity models including k–ε and other two-equation models, Reynolds-stress models, PDF approaches, and LES methods. The appendices provide very useful supplementary material. This reviewer found two appendices particularly useful, one dealing with Fourier transforms and the other containing the derivation of Eulerian PDF equations.

Several features distinguish this book from others in this field. For instance, exercises are provided at the end of each section rather than at the end of each chapter. These are quite useful as homework problems and also as a good supplement to the material covered in that particular section. Another notable feature is the extensive use of experimental and DNS data for validating various classical models and for elucidating the distribution of turbulent quantities in different turbulent flows, especially free shear and wall-bounded flows. This feature would help students develop appreciation for the usefulness and limitations of both DNS and modeling-based approaches. Other notable features include the following:

1) A detailed nomenclature at the beginning of the book.

2) Use of experimental and DNS data in discussing various time and length scales in turbulent flows.

3) Introducing a conserved scalar in the material on free shear flows (Chapter 5) and then revisiting it in the context of PDF methods in Chapter 12.

4) Detailed description of Eulerian and Lagrangian PDF and succinct discussion on the differences between the fluid and particle descriptions (Chapter 12).

The book can be used for two graduate-level semester courses. In the first graduate-level course on turbulence, the first seven chapters (Part I), along with Chapter 10, which deals with turbulent-viscosity models, can be covered. The second course can then focus on Reynolds stress models (Chapter 11) and DNS (Chapter 10), PDF (Chapter 12), and LES approaches (Chapter 13), along with related material from previous chapters. Several other combinations are, of course, possible.

In the opinion of this reviewer, the book is not lacking in any important aspect. However, if the author decides to write a second edition, one suggestion will be to add a chapter on two-phase turbulent flows, with appropriate material on dispersed-phase turbulence, including interaction between turbulence and inertial particles. The second edition could also contain additional material on the conserved scalar approach, which is presently discussed in Chapters 5 and 13. Finally, having a solution manual would greatly enhance the appeal of the book as a textbook.

In summary, the book should be well received in both academia and industry. It will be useful to students entering the field of turbulence as well as to experienced researchers and practicing engineers.

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