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BOOK REVIEWS

Turbulent Flows. By S. B. Pope. Cambridge University Press, 2000. 771 pp. ISBN 0 521 59886 9. £29.95 or $49.95 (paperback); ISBN 0 521 59125 2. £80.00 or $130.00 (hardback).

There is no need to explain the importance of the subject of this book to readers of *JFM*. I frequently hear the statement that turbulence is the great unsolved problem of classical physics. While such rhetoric serves nicely to emphasize how difficult progress in this field can be, I have to admit that I do not know what it means. Evidence that the Navier–Stokes equations are the appropriate laws of physics is compelling: there is no fundamental outstanding problem. That in no way lessens the need for innovative research, but the issue is how to describe the complex, irregular fluid motion governed by the Navier–Stokes equations. The appropriate type of description is a function of its use; there is no single problem to solve and no single solution towards which we are all striving. A great deal of progress along various paths has been made over the years. This book is a nice introduction to the field, and a survey of some of that progress.

Writing a book like this one is truly a challenge. The potential subject material is immense; bounds on the scope must be set and adhered to. Pope has done a good job in his selection of topics. Experts might wish that the emphasis were placed differently, or that certain material were covered more substantially. However, this book provides a framework that can be elaborated by a lecturer according to his or her preferences. It certainly will fill a need for course material.

The classic books in this field – Batchelor's monograph, Hinze's tome, Monin & Yaglom's encyclopedia, Tennekes & Lumley's textbook – do not suit the needs of a contemporary course on turbulence. The deficiency for students of engineering and applied science is the dearth of material on turbulence modelling. Pope has remedied that situation by adjoining a survey of ideas on closure modelling to an introduction to turbulence theory. The focus of the book is statistical theory, but a brief section on direct numerical simulation (DNS) is included, and a longer chapter is devoted to large-eddy simulation (LES). To a large extent, Pope's endeavour to produce a modern textbook is successful.

The book is divided into two parts: part I covers fundamentals; part II addresses modelling and simulation.

Part I of *Turbulent Flows* treats standard material: length and time scales; correlations and spectra; parallel and self-similar shear flows; Reynolds-averaged equations, etc. The treatment is directed toward students at graduate level. Pope relies heavily on exercises to convey the more technical material. Even if one does not solve the exercises, they should be read as part of the text. Indeed, they are interspersed with the narrative so that they appear in context.

What sets this book apart is part II. There, single-point turbulence closure modelling is covered at a level suited to graduate students. The industrial workhorses – mixing length variants and two-equation models – are described. Second-moment closure is also addressed. Some advanced topics are included: rapid distortion theory is introduced under the heading of 'Reynolds stress and related models'; integrity bases and explicit algebraic stress models are discussed (EASM was pioneered by Pope); elliptic relaxation for wall treatment is described; and references to the literature are given for other advanced material. Again, many important technicalities are relegated to exercises. The body of knowledge treated in part II is continually evolving; some of the material can be characterized as state of the art.

The topics on modelling are preceded by an 'introduction to modelling and simulation' which sets out criteria for appraising models. The criteria are: level of description, completeness, cost and ease of use, range of applicability, and accuracy. Each subsequent chapter includes a section entitled *discussion*, which is organized around those criteria. These sections are very valuable.

Those familiar with Professor Pope's research will not be surprised that the most demanding chapter is that on probability density function (p.d.f.) transport models. The primary motivation for p.d.f. modelling is reactive flow, so it surprised me that the application to reacting flow receives scant mention. I certainly would have preferred this chapter to begin with elementary material, such as the assumed p.d.f. approach and its application to fast reaction. Instead, it jumps right into the p.d.f. transport equation. This chapter will quite likely be difficult to integrate into a lecture course.

A similar bias exists in the chapter on statistical descriptions, contained in part I. Its focus is on p.d.f.s; however, the naive idea that the average of a set of samples can be computed as their sum divided by their number is left to the very end of the chapter. I would have preferred simple definitions of averaging to be stated at the outset, prior to the elaborate description of p.d.f.s. I will mention a few other complaints, but they can readily be addressed by a lecturer using *Turbulent Flows* for a course text.

There is a notable lack of examples to illustrate the use of Reynolds-averaged Navier–Stokes closure models. This often gave me the sense that topics were left in mid-air. The aim of these models is flow prediction; that pragmatic end is insufficiently recognizable in Pope's treatment.

The chapter on LES is even more notably devoid of illustrative examples. It describes the effect of filtering on spectra at length; it also describes the variety of subgrid schemes that have been explored in the literature; but no operational understanding is given of how LES is effected. Admittedly, a proper treatment of LES (and even more so DNS) would require a course on computational fluid dynamics. Pope's decision to treat simulation in a text on turbulence theory and modelling is admirable. However, I feel that the presentation would be improved substantially by illustrations showing simulated flow fields, by more description of the central numerical methods, and, in the case of LES, by figures comparing predicted statistics to data. I hasten to add that these shortcomings can be remedied: a lecturer should have little difficulty finding other sources of illustrations that can be used to introduce the material on simulation, and to flesh it out.

This book is a welcome addition to the literature on turbulence. It will serve well as a textbook.

P. Durbin

SHORT NOTICES

Modeling in Applied Sciences: A Kinetic Theory Approach. Edited by N. Bellomo & M. Pulvirenti. Birkhauser, 2000. 440 pp. ISBN 0 8176 4102 5. sFr 138 or DM 168.

This is a collection of ten review essays by different authors (misleadingly described as chapters). The essays, concerned with a wide range of phenomena, are unified only in the sense that all are concerned with statistical descriptions of a large interacting population and this often related in some way to the Bolzmann equation. There is no uniformity of treatment or notation between sections, nor is there an index. Topics include granular flows, chemical reactions, population dynamics, traffic flow and communication networks.

Nonlinear Waves in Multi-Phase Flow. Edited by H.-C. CHANG. Kluwer, 2000. 276 pp. ISBN 0 7923 6454 6. NLG 225 or $115 or £70.

This volume contains the proceedings of a IUTAM Symposium held in July 1999. There are 24 papers, concerned with free-surface phenomena and multiphase flows. The papers are grouped into sections concerned with thin-film waves, two-layer waves, bubbles and jets, wetting/dewetting, and bubbly and suspension flows. There is no index. The proof reading of the book is slip-shod: in at least one paper the figures are missing; in another cross-references to figures are absent.

Complex Flows in Industrial Processes. Edited by A. FASANO. Birkhauser, 2000. 348 pp. ISBN 0 8176 4087 8. sFr 138 or DM 168.

This volume is an eclectic choice of real-world fluid dynamical applications largely to complex fluids 'treated with mathematical rigour'. There are ten chapters by different authors (all from Italy and the Netherlands). Topics include: polymeric flows (including microstructural theory, crystallization, polymerization and spurt); glass; cold-water slurry pipelining; composite materials manufacturing; and porous media.