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Book Reviews

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Turbulent Flow

P. S. Bernard and J. M. Wallace, Wiley, Hoboken, NJ, 2002, 497 pp., $100.00

Jim Wallace is a very clever experimentalist, associated in my mind largely with a six-wire vorticity meter. Peter Bernard was trained at Berkeley, under the influence of Joel Chorin, and thus might be expected to have a few odd ideas about turbulence. They state, in the preface, that their book consists of the notes for two courses on turbulence. There seems to me to be an enormous amount of material here, and I find it hard to imagine graduate students I know absorbing all of it in the time available in two courses. In addition, the price of $100 for the volume seems to me to preclude its use as a text. Because so much material is covered, few subjects are covered in any great depth or with a great deal of physical insight; the emphasis seems to be rather on equations and simple models.

The book begins with an Overview of Turbulent Flow Physics and Equations (Chapter 2); then Experimental and Numerical Methods (Chapter 3), followed by Properties of Bounded Turbulent Flows (Chapter 4) and Properties of Turbulent Free Shear Flows (Chapter 5). With the exception of Chapter 3 (which reflects the background of Wallace), this material is not unlike that found in Tennekes and Lumley, *A First Course in Turbulence*, for example.

Then we have Turbulent Transport (Chapter 6), which I suspect was written by Bernard and gives a slightly idiosyncratic view of transport, but with considerable physical insight. Next we have Theory of Idealized Turbulent Flows (Chapter 7), which is to say, isotropic and homogeneous flows. This is followed by Turbulence Modeling (Chapter 8) and Applications of Turbulence Modeling (Chapter 9). There is, of course, an enormous amount of material in the literature on turbulence modeling and its applications, and these chapters cannot be anything more than a once-over-lightly. They are heavily influenced here by Speziale, which may not be entirely a good thing, although (following Speziale) the authors get right the complex subject of material frame indifference applied to turbulence.

But wait; we are not done yet! We have Large Eddy Simulations (Chapter 10), Analysis of Turbulent Scalar Fields (Chapter 11), and Turbulence Theory (Chapter 12). Chapter 11 deals (at least in part) with buoyancy, and Chapter 12 gives what might be described as summaries of Gaussian random fields, the EDQNM approach, the direct interaction approximation, the renormalization group approach, and the thermodynamics of vortex systems (Chorin's influence). My feeling is that all of these approaches are too complex (and not of enough use) to have a place in a turbulence course. They might be the subject, explored for their intellectual interest, of a reading course for advanced students. To be fair, these brief summaries probably represent about as much as the average student needs to know about these approaches, unless he or she is going to specialize in one of them.

It would be unkind to point out that the authors have left out the kitchen sink. On a serious note, the market is presently flooded (to exaggerate only a little) with books on turbulence: Pope, Mathieu and Scott, Frisch, Chassaing (in French). We should try to place the present volume somewhere in this group. Of these, Chassaing and Mathieu and Scott are the only ones that make a real pedagogical effort, in quite different ways but both with plenty of physics; I could be comfortable teaching a course from either one. Pope is encyclopedic, and by picking and choosing material, a course could be constructed. Frisch is a physicist's point of view, and in my view quite unsuitable as a text for the students that we train at Cornell. I am afraid I feel that Bernard and Wallace also isn't really suitable as a text, nor is it suitable as reading for a specialist trying to get into the field.

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Turbulent Flow Computation

Edited by D. Drikakis and B. J. Geurts, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2002, 369 pp., $87.00

As stated by the editors, this book aims to provide the reader with timely information on selected state-of-the-art practices and to delineate several outstanding challenges in the field of turbulent flow computation. Although the title is rather broad, the book is centered on direct numerical simulation (DNS) and large-eddy simulation (LES) approaches, as well as on the design and reliability of the numerical techniques required for such high-fidelity applications. The publication of this book is timely, given the current impetus to extend LES methodologies to increasingly more complex flows of engineering interest. The contributing authors are also, without a doubt, leading researchers in their respective fields of turbulence simulation, numerical analysis, and computational fluid dynamics (CFD).

The book is composed of 10 essentially independent chapters, arranged in no discernible order, with the exception of Chapters 8–10, which focus on applications and challenges in geophysical, multiphase, and aerospace/automotive flows, respectively. One of the key contributions of the book is the effort made to characterize both the qualitative and quantitative errors likely to be encountered in DNS/LES studies. This includes the behavior of underresolved spectral simulations (Chapter 1); issues associated with symmetry-preserving discretizations (Chapter 3); the analysis and control of truncation, aliasing, and commutation errors (Chapter 4); and the spurious dynamics of numerics (Chapter 6). Lessons learned from these studies are quite valuable for the improvement and proper interpretation of practical turbulence simulations. For instance, the work of Chapter 4 clearly demonstrates the need for high-fidelity algorithms (such as Pade-type schemes) in order to keep truncation error below acceptable levels. The book provides extensive information on the design and application of adaptive spectral methods for unstructured meshes (Chapter 1), as well as high-order adaptive low-dissipation schemes (Chapter 5). Implicit sub-grid-scale (SGS) models embedded in the truncation error properties of high-resolution methods for hyperbolic equations are addressed in Chapters 2 and 8, where both a justification is forwarded for their use and their efficacy is documented. Chapter 7 discusses the so-called LES-α modeling approach and gives extensive information on its background and its relationship to other regularizations and SGS models, as well as its numerical stability characteristics in the context of canonical flows (e.g., turbulent mixing layer). The importance of explicit filtering and numerical spatial accuracy is also highlighted in this chapter. Finally, although of general interest for practical applications, Chapter 10, which gives examples of CFD simulations, is perhaps not aligned so well with the main theme of the book.

On the basis of this brief description of its contents, it is clear that this book's emphasis lies on the description and assessment of several DNS/LES methodologies rather than on the latest applications. In this regard, it represents a good complement to recent volumes published under the same Kluwer Fluid Mechanics Series, which were devoted to applications in a wide range of engineering problems. In addition, the extensive bibliographies included in all chapters provide an excellent source for citations to key contributions in the field, including the original papers on which much of the material is based.

Several important themes emerging from the collective contributions are worthy of summary, in particular because some of these views, while perhaps widely recognized by many practitioners, still lack rigorous formalism. Among the important topics addressed by the authors, the following recurring ones may be cited: 1) limitations and unclear promise of standard SGS modeling approaches, 2) the potential and need for proper characterization of alternative implicit LES methods that exploit the inherent numerical dissipation characteristics of computational algorithms, 3) the importance of understanding the impact on the computed flow physics of the unavoidable numerical approximations and limited spatiotemporal resolution, and 4) the ever-present need for efficient high-resolution/low-dissipation schemes for both compressible and incompressible simulations applicable to general geometries.

Although not quite fitting as a main-course textbook, *Turbulent Flow Computation* provides an excellent source of complementary material for graduate students and should appeal to scientists and engineers involved in the advanced simulation of turbulent flows.

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