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Book Reviews

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Turbulence—An Introduction for Scientists and Engineers

P. A. Davidson, Oxford University Press, New York, 2004, 678 pp., \$69.50 (soft cover), \$174.50 (hard cover)

Books devoted to turbulence have appeared at somewhat more than one per year over the past decade. The treatments have varied greatly, partly because different authors have written for different audiences but mainly because the authors' views of turbulence have differed greatly. It is generally agreed that turbulence in simple fluids is described by the Navier–Stokes equations and that the most straightforward approach to the turbulence problem is to solve those equations numerically. It is also agreed that these direct numerical simulations are currently limited to fairly simple geometries and fairly low Reynolds numbers and that computing power will have to be increased by many orders of magnitude before complex flows at high Reynolds number can be calculated. Engineers and Earth scientists need less demanding prediction methods that are in some sense approximations to the Navier–Stokes equations. This is where individual initiative and individual opinions come in. Dr. Davidson says, "The subject tends to consist of an uneasy mix of semi-empirical laws and deterministic but highly simplified cartoons . . . ," and one's only objection is that "laws" is too kind a word for the equations or formulas that constitute present-day prediction methods.

Dr. Davidson's 670-page book begins with three chapters on the general nature of turbulence and some of the relevant equations derived from the Navier–Stokes equations. There is a useful discussion of the dynamics of vorticity, which is in some ways a more fundamental variable than velocity. Chapter 4 deals with prediction methods ("closure models") for shear flows. Readers for whom this is the main motivation for studying turbulence may find this chapter unsatisfactory because it is not a complete review. However, it contains a great deal of useful insight and, like the other chapters, ends with a list of references, mostly accompanied by one-sentence abstracts—a very useful feature. Chapter 5 is a continued discussion of turbulence dynamics with an emphasis on vorticity. Dr. Davidson inclines to use spatial correlations rather than wave-number spectra: because Kolmogorov did the same one can hardly complain, and indeed correlations may seem more natural to a student.

Part II of the book, three chapters and 200 pages, deals with homogeneous, then isotropic, turbulence. This is where analytical work on turbulence has made the most progress, but extensions to inhomogeneous flows are generally inexact or qualitative, providing insight rather than numbers.

Part III is a discussion of two very different special topics, body forces and two-dimensional turbulence. Once again, the discussion of body forces provides useful insight, even for readers with no special interest in the subject. This reviewer regards two-dimensional turbulence as undeserving of the name because it lacks the essential feature of true turbulence, vortex stretching: however, it is an interesting phenomenon and, of course, is a good approximation to synoptic-scale motion in the atmosphere.

In summary, this is a very readable book, and the mathematics should be well within the capacity of a graduate engineer or physicist. It is not a list of facts like some books or reviews. The facts are there but embedded in a careful and sometimes leisurely discussion. A reader with time to read it from cover to cover will find the time well spent.

Peter Bradshaw
Stanford University