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BOOK REVIEW

An Informal Introduction to Turbulence. By A. TSINOBER. Kluwer, 2002. 324 pp. ISBN 1 4020 0110 X. €120 or $110 or £76.

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By the end of the 1990s it was clear that the time was right for a new introductory text on turbulence. Tennekes & Lumley's excellent book had been in service for almost thirty years and was beginning to look a tad dated. The popular monographs of Lesieur and Frisch ably documented important advances in the subject, but neither is well adapted for teaching, nor readily accessible to the novice. So perhaps it was not so surprising that, from 1996 onwards, a wave of new introductory books began to appear. Perhaps the first was Libby (1996), quickly followed by Mathieu & Scott (2000), Pope (2000) and Durbin & Pettersson-Reif (2001), to name but a few. *An Informal Introduction to Turbulence*, by Arkady Tsinober, is the latest offering.

What can be said about this book? Well, perhaps the most important point to make is that, despite the title, or claims made in the preface, this is not a suitable introduction for the novice. Consciously, or subconsciously, the author has aimed the book at his peers, and not at the uninitiated. For example, there is little attempt to provide a mathematical framework for the subject which, although ultimately of limited value, does provide the newcomer with a 'security blanket', giving the illusion of progress and structure. Nor does he provide us with a road map for turbulence, outlining the broad subdivisions within the subject: boundary layers, free shear layers, homogeneous turbulence, etc. (In fact, the book is almost entirely devoted to homogeneous turbulence.) So a reader embarking on a study of turbulence will, on first opening the book, rapidly become disoriented and confused by the apparent lack of structure. This situation is not helped by the large number of typographical errors†, the uneven English, and the poor reproduction of figures and plates.

So, if Tsinober is not seeking to educate the novice, what is he trying to do? In the opinion of this reviewer, his primary motivation seems to be to provoke his peers into re-examining their preconceived notions. Throughout the book he lines up a series of sacred cows, such as the energy cascade, the claim for universality in the small scales, and scale invariance in the inertial subrange, and one by one he takes these concepts apart, exposing their weaknesses. Indeed, one gets the impression that the author embraces each new controversy with some relish. The tone of the writing, and the nature of the subject material, is epitomized by Appendix D, which is entitled 'It is a Misconception That'. Some of the author's attacks on received wisdom hit their mark: others are less convincing. Many make interesting reading.

Chapter 1 consists of a (very) brief history of the subject, an overview of the qualitative features of turbulence, and a discussion of why a theory of turbulence has proven to be so elusive. Here Tsinober emphasizes that the difficulty arises not just from the non-linearity of the Navier–Stokes, but also from the non-local nature of the Biot-Savart law which relates $\boldsymbol{u}$ to $\boldsymbol{\omega}$. On page 23 we encounter for the first time what

† For example, three lines of text are repeated on page 24, Mathieu's name is incorrectly spelt in the first paragraph of the preface, and the missing page 150 and incorrect labelling of figures in chapter 9 necessitated an *errata*.

is to become a recurring theme: his insistence that there is a direct, two-way coupling between the large and small scales; a coupling which is enforced by the Biot-Savart law. Of course, such a view runs contrary to the conventional interpretation of the energy cascade.

Chapters 2 and 3 are extremely short. Chapter 2, which is a mere five pages long, is entitled: 'Origins of Turbulence'. There is some discussion of chaos and of routes to chaos, but the arguments are too brief to add weight to the book. Chapter 3 discusses methods of describing turbulence. Here Tsinober outlines the need for a statistical approach to the subject and emphasizes that statistical theories do not, in any sense, exclude the idea of coherent structures. On page 42 we meet again the argument that there is a direct interaction between the small and large scales.

In many ways Chapters 4, 5 and 6 represent the core of the book. Chapter 4, on kinematics, provides an interesting discussion of material line stretching and of the kinematics of passive vector fields. It also includes a discussion of chaotic advection in laminar flows. Chapter 5, which nicely complements Frisch's (1995) book, focuses on cascades and Kolmogorov's theory of the small scales. It starts with a careful assessment of Kolmogorov's similarity hypotheses and of the local isotropy hypothesis, which is now known to be seriously flawed. This is followed by a discussion of cascades and scales. Here Tsinober associates the term 'small scale' with the vorticity field, or more precisely the field of velocity gradients (see also page 86), and again argues that there is a direct, two-way coupling between large and small scales. The logic goes something like this: we do not have a clear definition of what constitutes 'small scale' and 'large scale' in turbulence, but we do agree that, in some sense, most of the enstrophy seems to be small scale and most of the energy is large scale. Let us, therefore, take all that is vorticity to be small, and all that is velocity to be large. It follows immediately from the Biot-Savart law that the small and large scales talk to each other. As an illustration of this coupling we are offered (on pages 42 and 120) the example of a shear flow, where the cross-stream gradient in Reynolds stress, $\mathrm{d}\langle u_1 u_2\rangle/\mathrm{d}x_2$, can be written as $\langle(\boldsymbol{\omega}\times\boldsymbol{u})_1\rangle$. The non-zero gradient in Reynolds stress implies a non-zero correlation between $\boldsymbol{u}$ and $\boldsymbol{\omega}$ and since $\boldsymbol{\omega}$ is small while $\boldsymbol{u}$ is large, we are told that there must be a correlation between large and small scales.

Perhaps a more traditional argument would be that there is both small-scale and large-scale vorticity. The large-scale vorticity is weak and dispersed, and so adds little to the enstrophy, while the small-scale vorticity is intense, irregular and random, and so dominates the enstrophy but adds little to the energy. The Biot-Savart law then connects the (weak) large-scale vorticity to the large-scale velocity and small-scale vorticity to the (weak) small-scale velocity. So in the shear flow, for example, the fact that $\langle(\boldsymbol{\omega}\times\boldsymbol{u})\rangle$ is non-zero is indicative of the interaction of large-scale vorticity with large-scale velocity (e.g. in hairpins), rather than any interaction between small and large scales. This picture is rather different to that offered by Tsinober.

Chapter 6, which is easily the longest in the book, focuses on dynamics. There is much discussion of vortex stretching and of the interplay of the strain and vorticity fields. The main novelty of the chapter lies in the fact that, rightly or wrongly, Tsinober places the strain field on an equal footing with the vorticity field. There is some interesting material on 'geometrical statistics' (e.g. the typical relative orientation of the strain and velocity fields).

The book concludes with a brief discussion of intermittency and turbulent structures (Chapter 7) and of non-isotropic turbulence of the type seen in shear flows, stratified fluids, and MHD (Chapter 8). The various sections in Chapter 8 are too brief to be of much value.

So what are we to make of this unusual book? As noted at the beginning of the review, it is not, as the title might suggest, an accessible introduction for the newcomer to turbulence. It pre-supposes too much on the part of the reader. It does, however, address many important topics often glossed over in introductory texts, including a number of controversial issues which are usually delicately side-stepped. It so happens that this reviewer disagrees with some of the views expressed, but that is neither here nor there. The important point is that these difficult issues are being aired and that is, perhaps, the strength of the book.

REFERENCES

Durbin, P. A. & Pettersson-Reif, B. A. 2001 *Statistical Theory and Modelling for Turbulent Flows*. Wiley.

Frisch, U. 1995 *Turbulence: the Legacy of A. N. Kolmogorov*. Cambridge University Press.

Libby, P. A. 1996 *An Introduction to Turbulence*. Taylor & Francis.

Mathieu, J. & Scott, J. 2000 *An Introduction to Turbulence Flow*. Cambridge University Press.

Pope, S. B. 2000 *Turbulent Flow*. Cambridge University Press.

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SHORT NOTICES

Early Developments of Modern Aerodynamics. By J. A. D. Ackroyd, B. P. Axcell & A. I. Ruban. Butterworth-Heinemann, 2001. 248 pp. ISBN 0 7506 5133 4. £65.00.

J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S002211200222337X

The bulk of this book consists of the seminal papers on aerodynamics, some said not to have been previously available, in translation, from Kutta, Prandtl, Zhukovskii, Blasius and Chaplygin. For each one the authors provide a one-page commentary pointing up the modern significance of the ideas being expressed for the first time. The early parts of the book provide a historical introduction to the subject up to the nineteenth century.

Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena. By Ya. B. Zel'dovich & Yu. P. Raizer. Dover, 2002. 916 pp. ISBN 0-486-42002-7. $34.95.

J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002233376

Dover have now produced a single paperback version of the two-volume English translation of this classic work (first reviewed in JFM in volumes 31 and 33, 1968). It is edited by W. D. Hayes & R. F. Probstein who have made further changes to the text, including the addition of explanatory notes and source notes.

Atmosphere-Ocean Interactions, Vol. 1. Edited by W. Perrie. WIT Press, 2002. 312 pp. ISBN 1-85312-892-9. €224.60 or £138.00.

J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002243372

Nine separate chapters by different authors reviewing sea spray generation, tropical cyclones, storm simulation and boundary layer models for ocean and atmosphere. No index.

Advances in Fluid Mechanics IV. Edited by M. Rahman, R. Verhoeven & C. A. Brebbia. WIT Press, 2002. 736 pp. ISBN 1-85312-910-0. £245 or $382 or €398.74.
J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002253379

Papers, at a price, presented at a conference held in Ghent in 2002. More than 50 multiauthored contributions. No unifying theme or index.

Closure Strategies for Turbulent and Transitional Flows. Edited by B. Launder & N. Sandham. Cambridge University Press, 2002. 754 pp. ISBN 0 521 79208 8. £85 or $120.
J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002263375

A third book (in addition to those edited by Hunt and Vassilicos mentioned in JFM volume 444) to originate from the Turbulence Programme at the Isaac Newton Institute in 1999. This volume has 26 multiauthored papers; we are told that contributions have been "updated wherever possible [since 1999] to take account of the most recent developments". Again no index!

Free Surface Flows. Edited by A. C. King & Y. D. Shikhmurzaev. Kluwer, 2001. 360 pp. ISBN 0-7923-7085-6. £82.00 or $117.00 or €135.00.
J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002273371

This volume presents the proceedings of the IUTAM Symposium held in Birmingham, UK, in 2000. There are four short review papers (38 pp. in total) on bubble dynamics, thin film flows, dynamic wetting and water waves. In addition 40 research contributions are included. There is no index.

Environmental Stratified Flows. Edited by R. Grimshaw. Kluwer, 2001. 283 pp. ISBN 0-7923-7605-6. £92.50 or US$135 or €150.
J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002283378

Here are eight multiauthored chapters that aim to provide a state-of-the art account of stratified flows in the ocean and atmosphere. Topics include internal solitary waves, flow over topography, turbulence, instability and laboratory studies.

Flow-Induced Vibrations in Engineering Practice. Edited by P. Anagnostopoulos. WIT Press, 2002. 388 pp. ISBN 1-85312-644-6. £132.00 or €214.83.
J. Fluid Mech. (2003), *vol.* 475. DOI: 10.1017/S0022112002293374

Another book in the Advances in Fluid Mechanics series from WIT Press consisting of five invited and multiauthored chapters. Production values are poor with damaged pages, no uniformity of typeface, no index and some figure lettering too small to read.