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BOOK REVIEWS

Stellar Magnetism. By Leon Mestel. Oxford University Press, 1999. 636 pp. ISBN 019 851761 0. £85.

It was a real pleasure to hold this magnificent tome in my hands for the first time, to savour it and eagerly to read through its pages. Written by a world authority on cosmic magnetism, it is likely to become a classic in its field.

The fundamental role of magnetic fields in many astrophysical phenomena is now widely recognised. An attempt to understand that role in all its richness and diversity represents one of the most lively and active branches of modern fluid dynamics and astrophysics. The present book will be welcomed in playing a major part to aid and encourage the development of such understanding.

Recent Space observations are beginning to reveal some of the basic properties of the Sun and are a major stimulus in the development of theories for cosmical magnetism. But these are complemented by observations of other stars in much more extreme states than our Sun and at earlier epochs. Many stars possess activity cycles, hot coronae and winds, while others without extensive convection zones have fields that are well modelled as obliquely rotating magnetic dipoles with fields of 10^3 G. Condensed stars can possess much stronger fields, namely typically 10^7 G in white dwarfs and 10^{12} G in rotating neutron stars that show themselves as pulsars.

Although the book focuses on the magnetism of stars, many of the processes discussed and lessons learnt are of much wider application in other parts of the universe – for example, the dynamos, accretion discs, jets and winds seen in galaxies and active galactic nuclei.

Leon Mestel gives a self-contained and highly comprehensive coverage of stellar magnetism, including magneto-convection, dynamo generation of magnetic fields, magnetic braking by winds of stellar rotation, and particularly thorough accounts of star formation and the pulsar magnetosphere. Throughout, he reveals his deep physical insight with typically shrewd turns of phrase and complements it with the necessary mathematical detail in impressive classical style. The way he describes the development of each subject and indicates the limitations of current theory is especially useful.

The first four chapters give an introduction to the subject, including a brief account of the history and observations, together with the basic equations, the motions of waves, magnetic equilibria, stability, magnetic reconnection, and an extensive discussion of magneto-convection. Chapter 5 outlines the behaviour of magnetic fields in stellar interiors as a preparation for a critical account in chapter 6 of the progress so far in understanding the dynamo generation of stellar magnetic fields. Chapter 7 describes how the rotation of stars may be braked by magnetic fields, which leads to a provisional understanding of the rotational history of late-type stars (chapter 8) and of pre-main sequence stars and magnetised accretion discs (chapter 10). Many early-type stars on the other hand, behave as non-axisymmetric oblique rotators (chapter 9). The effect of magnetic coupling on star formation is treated in depth in chapters 11 and 12. Finally, the still unsolved pulsar magnetosphere problem that has captivated Mestel for many years is described in chapters 13 and 14.

This remarkable book is essential reading for all wanting an up-to-date and authoritative account of the key role of magnetic fields in modern astrophysics – indeed, without a full appreciation of this role a twenty-first century astronomer would be severely handicapped.

E. R. Priest

Turbulent Flows: Models and Physics. By Jean Piquet. Springer, 1999. 761 pp. ISBN 3 540 65411 9. DM 298.

This is a book on single-point moment-closure modelling. One might protest that this is too narrow a description of its scope. However, the book makes clear that single-point modelling is not divorced from the remainder of turbulence research. Perusing the table of contents, one sees that two-point, spectral theory is included and that the second half of the book extensively surveys experiments on turbulent shear flow. However, upon reading the text, one finds that the connection to single-point modelling is a recurrent theme that colours the manner in which almost every topic is treated.

With advances in computer technology, and with the development and marketing of robust computational fluid dynamics codes by commercial software companies, an increasing number of industries are discovering that fluid dynamical components of their processes can be analysed. In many cases single-point turbulence models are central to the expanded usage of CFD. Recognition of the role that turbulence models play has produced an, admittedly modest, surge of interest in closure modelling. A book on the subject is certainly timely. But, I must hasten to add that I do not recommend *Turbulent Flows: Models and Physics* to applied computational fluid dynamicists, or to casual readers, or, especially, to new students of the subject. This book is an extensive survey that might be of interest to one who is knowledgeable in the field and wants to fill gaps in that knowledge. I expect that in most cases those gaps would be filled by pursuing the literature cited in the very comprehensive bibliography. Piquet's treatment is often sketchy.

I wholely disagree with the book jacket's implication that this book is 'a quick route through the jungle of publications and models'. This is not a text for the uninitiated: the development is fragmented and not easily readable. It is riddled with mistakes: misspelled words, grammatical errors, miscited equations and errors in formulas all abound. A good deal of effort must have gone into producing the manuscript for this book; it is unfortunate that the proofreading of the final text is so poor.

The book begins with a chapter on the Navier–Stokes equations and kinematics. It is largely a pastiche of material gleaned from the literature. It is not a mathematical background for the rest of the text, *per se*. This sets the tone for the entire book: the approach is to cite a great deal of material, without a progressive, systematic development. The virtue of such an approach is that it informs the reader of the many aspects of a topic. The weakness of not being selective in the material covered is that the book cannot be used pedagogically.

Chapter 2, on principles of modelling, discusses Reynolds averaging, characteristic length scales, eddy viscosity, etc. Practical kinds of models, such as k–ε and k–ω appear here. The emphasis is on k–ε, which is appropriate, given its widespread use in commercial CFD codes. Piquet cites almost every modification to this model that has ever been proposed – irrespective of whether or not it has been productive. The epitome is his truly bewildering tabulation of 'low Reynolds number' damping schemes. Oddly, the more effective 'two-layer' approach to extending k–ε to the near-wall region receives scant mention. Closed-form solutions, which are crucial to understanding these models, can be found here and in chapter 4.

Chapter 3 covers two-point analysis for homogeneous turbulence and rapid distorsion (*sic*) theory. Classical material on spectral representation, isotropic turbulence, triad interactions and Kolmogoroff theory is covered. The unique element to Piquet's treatment is the inclusion of numerous connections to single-point modelling. For instance equations for the dissipation tensor are derived that contain two-point correlations in the limit of $r \to 0$. The author states that these may be used as a starting point for refined modelling of the ε equation. As another example, the 'dimensionality', 'circulicity' and 'stropholysis' tensors are defined. These were introduced by Kida & Hunt, Cambon *et al.* and Kassinos & Reynolds for single-point 'structure based' modelling.

The section on rapid-distortion theory is restricted to the classical development for homogeneous turbulence. The treatment is thorough, including recent re-examinations of the subject. Regrettably, non-homogeneous RDT is omitted.

After the discussion of two-point theory, the book returns to single-point modelling in a chapter on second-moment closure. The coverage is thorough. The chapter opens with a listing of nine mathematical constraints that guide modelling. They include essentials, like coordinate-system independence and consistency with log-layer scaling. The listing of constraints would have provided a nice framework to organize the chapter. Unfortunately that was not done. The manner in which these principles are implemented can be inferred in many cases, but the development is disorderly and clouded by masses of formulae that are presented without derivation. It is unlikely that the uninitiated reader would reach this point in the book. However, such a reader would gain little insight into the state of the art in second moment closure. Indeed, many of the models cited in appendix A as 'the most useful' have either been abandoned, or in one case, never been used for practical flow prediction.

Chapters 5 and 6 constitute half of the book. In my estimation this is the more valuable half. It describes basic flows that are used to calibrate and to test closure models. The literature survey guides one to the available data on each flow. Chapter 5 covers canonical quasi-parallel flows: boundary layers, jets and wakes. Complicating factors such as co-flow and swirl are addressed. The only aspect that might raise some eyebrows is the author's decision to omit mixing layers. His rationale is that mixing layers are extremely sensitive to initial conditions; he dismisses the mixing layer as a 'pathological case' that is dominated by spanwise vortex rolls. My understanding of the literature is different: streamwise vortices are the dominant structures in fully turbulent flow, and two-stream mixing layers are not excessively dependent on upstream conditions. Aside from this debatable omission, chapter 5 is a useful compilation.

Chapter 6 covers 'complex effects' in boundary layer and channel flows. Complexity is defined relative to canonical flows, not to engineering flows. Curvature, pressure gradients, crossflow, surface roughness, and similar topics are discussed. This chapter is a good resource to locate data for preliminary testing of turbulence models designed for engineering flow prediction.

It is customary to conclude a review with a suggestion of where the book will be housed. My guess is that this one will find its primary home on library bookshelves and in the office of specialists in the field of single-point closure modelling.

P. A. Durbin

SHORT NOTICES

Wind-over-Wave Couplings. Edited by S. G. Sajjadi, N. H. Thomas & J. C. R. Hunt. Oxford University Press, 1999. 356 pp. ISBN 019 850192 7. £110.

This book is primarily devoted to the proceedings of a conference that took place in Salford in April 1997. One of the contributors is James Lighthill, and the book starts appropriately with Julian Hunt's address at Lighthill's funeral. There are 32 papers altogether arranged around three themes – generation of water waves by wind; dynamics of water waves, and effects of turbulence near the surface of water waves; and the consequences of ejection of particles from surfaces. The papers are quite short; many (e.g. J. T. Stuart's Benjamin memorial lecture on the Benjamin–Feir instability) are largely of a review character. The volume will be found useful as a reference work, though, unfortunately there is no index.

Mixing: Chaos and Turbulence. Edited by H. Chate, E. Villermaux & J.-M. Chomaz. Kluwer, 1999. 396 pp. ISBN 0 306 46195 1. £97.25.

This volume derives from a NATO Advanced Study Institute held in July 1996 in Cargese, France. The contributions listed below are intended to be accessible to non-specialists in mixing, and generally succeed in that aim. The book is therefore a good introduction to different aspects of the subject though the index is rather skimpy. Topics and authors are

A philosophical and historical journey through mixing and fully developed turbulence, by M. Farge & E. Guyon (26 pp.);
Mixing: turbulence and chaos – An Introduction, by E. J. Hinch (22 pp.);
Turbulence, fractals, and mixing, by P. E. Dimotakis & H. J. Catrakis (86 pp.);
Scale-dependent fractal geometry, by H. J. Catrakis & P. E. Dimotakis (18 pp.);
Comparing extremes: mixing of fluids, mixing of solids, by J. M. Ottino & T. Shinbrot (24 pp.);
Scale covariance and geometry in turbulent combustion, by A. Pocheau (20 pp.);
Dynamics of Lagrangian tracers in barotropic turbulence, by A. Provenzale, A. Babiano & A. Zanella (22 pp.);
Transport, stirring and mixing in the atmosphere, by P. Haynes (44 pp.);
The ozone hole, by B. Legras (14 pp.);
The effect of Schmidt number on stratified entrainment, by A. J. Cotel (20 pp.);
Dispersion at large Péclet number, by Y. Pomeau (10 pp.);
An introduction to chaotic advection, by J. H. E. Cartwright, M. Feingold & O. Piro (36 pp.);
Renormalization group method in chaotic mixing, by G. M. Zaslavsky (19 pp.);
Fluctuations and mixing of a passive scalar in turbulent flow, by B. I. Shraiman & E. D. Siggia (24 pp.);
Cascade models of turbulence and mixing, by L. P. Kadanoff (10 pp.).

Fundamental Problematic Issues in Turbulence. Edited by A. Gyr, W. Kinzelbach & A. Tsinober. Birkhauser, 1999. 496 pp. ISBN 3 7643 6150 6. sFr 198, DM 238.

This book records the 46 papers presented at a colloquium held in Monte Verita, Switzerland in March 1998. It is reported by the editors that the time available for discussion at the meeting was much longer than normal, unfortunately those discussions are not included. Papers are grouped into sections concerned with: mathematical issues; control; observations; two-dimensional flows; modelling; statistical aspects and passive objects.