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BOOK REVIEWS

Rayleigh–Bénard Convection; Structures and Dynamics. By A. V. GETLING. World Scientific, 1998. 245 pp. ISBN 981 022657 8.

The phenomenon of thermal convection due to temperature dependence of density in an unstably stratified fluid has been the subject of a huge body of research since Rayleigh first solved the linearized stability problem in idealized form in 1916. (Bénard's original convection cells in spermaceti, with hexagonal symmetry, are now known to be due to the temperature dependence of surface tension.) The attraction of the problem is clear; the governing equations are of particularly simple form in the Boussinesq approximation, the phenomenon can be reproduced in the laboratory using common fluids, and the onset of instability is (essentially) supercritical, in contrast to pipe flow. Thus the initial form of instability may be investigated by linear and weakly nonlinear analysis, and by the solution of simplified model problems. For many years the standard text was that of Chandrasekhar, who covered the linearized stability problem in the Boussinesq approximation in enormous detail. It is curious in retrospect that it took until the 1950s for the nonlinear problem to be tackled by perturbation theory, since many of the tools were present in the literature on ordinary differential equations. Since the 1960s we have seen the development of the theory of bifurcations with symmetry, vast improvements in numerical simulation and, perhaps most importantly, a number of very precise experiments designed to tease out subtle properties of weakly nonlinear flows. The present monograph has as its main aim to give an overview of modern developments. In my view it succeeds well in this, giving anyone wishing for background information in the area a coherent discussion of most of the important theoretical questions backed up by a comprehensive and up-to-date bibliography.

In the introduction the author makes his biases explicit: he is really concerned with the shape, size and time dependence of cellular flows (loosely defined) near the onset of instability. There is very little treatment of non-Boussinesq effects, and already by the third page of Chapter 2 ('Basic concepts') we have reached the Boussinesq approximation, with few details of its derivation and limitations. As is appropriate in view of the extensive treatment of Chandrasekhar, the linearized stability problem is dispensed with in a few pages, and we are then on to the main theme of pattern selection. The main vehicle for his exegesis is the class of equations which might be called envelope equations, together with model systems such as the Swift–Hohenburg equation. The derivation of correct envelope equations to describe long-wavelength modulation of locally roll-like solutions is a difficult problem; the role of large-scale mean flows has only recently been understood. The Newell–Passot–Souli equations (which incorporate the most effects, but are almost as hard to solve as the full problem) are treated only briefly. The difficulty with simpler models, such as the Newell–Whitehead–Segel equation, is that their dynamics is variational, precluding recurrent phenomena such as the recently discovered spiral-defect chaos. Thus the most interesting types of motion can even now only be described rather than analysed in detail. However, the author is able to integrate the theoretical and experimental approaches satisfactorily.

The main section of the book concerns the author's principal interest: the nature of the mechanism of wavelength selection for cellular patterns. There is a wide variety

of experimental and theoretical work on this topic, and this is summarized in a careful and critical manner. There are in fact many different ways in which roll sizes can be selected (propagation of dislocations, selection by moving fronts, constraints due to boundaries...) and these give different answers in general. Perhaps more could have been made of the greater variety of routes to length-scale selection available for two-dimensional patterns compared to one-dimensional ones. Perhaps less emphasis could have been placed on variational techniques for constructing optimum scales. Nonetheless I found this part of the book especially useful and thoughtful.

The final part of the book discusses applications of convection theory to e.g. the solar convection zone and the Earth's mantle. This section is very brief, however, and does not give more than the barest introduction to the very wide range of subjects covered. A reader seeking a truly comprehensive treatise will find other things missing, for example a proper discussion of strongly nonlinear convection and convective turbulence. Nor is there a serious attempt to incorporate the recent advances in equivariant bifurcation theory into the description of pattern formation. These are minor criticisms, however. There are no other texts covering similar ground and I believe that this book will be especially useful to any graduate student who wishes to understand modern developments in the theory of convection.

M. R. E. Proctor

SHORT NOTICES

Nonlinear Dynamics, Chaotic and Complex Systems. Edited by E. Infeld, R. Zelanzny & A. Galkowski. Cambridge University Press, 1997. 326 pp. ISBN 0 521 58201 6. £50.

This book is an outcome of a conference held in Zakopane, Poland in November 1995, and contains 21 of the 23 plenary invited lectures. The meeting clearly had an international flavour with most participants from all parts of Europe, and a few from elsewhere. A lot of ground was covered, and the plenary lectures reported here are divided into the following categories: dynamical systems, bifurcation theory and chaos (V. Gundlach; B. Hunt & E. Ott; G. Karolyi; A. Pentek; T. Tel & Z. Toroczkai; L. Shilnikov); spatially extended systems (I. Bialynicki-Birula; P. Hasal, V. Nevoral, I. Schreiber, H. Sevcikova, D. Snita & M. Marek; V. Lvov & I. Procaccia; M. Markosova; F. Spineanu); dynamical chaos, quantum physics and foundations of statistical mechanics (L. Bunimovich; B. Chirikov; J. Dougherty; W. Hoover, H. Posch, Ch. Dellago, O. Kum, C. Hoover, A. De Groot & B. Holian; B. Pavlov, I. Prigogine & D. Driebe); evolutionary and cognitive systems (W. Ebeling; H. Szu & Ch. Hsu; C. Vanden Broeck & G. Bex; A. Vanecek & S. Celikovsky; H. Wozniakowski); and complex systems as an interface between natural sciences, environmental, social and economic sciences (V. Makhankov). There is also a transcript of a fascinating conference banquet talk by M. Feigenbaum. In addition there were 212 contributed talks which will be published in the *Journal of Technical Physics*, and four panel discussions whose outcomes are described briefly in the preface to this volume.

Overall, this book is a useful guide to current directions in nonlinear dynamics and the many diverse applications. The articles are based on lectures given to a broad audience, and on the whole, are pitched at this level. While readers of *JFM* will find only a few articles specifically directed towards fluid flows, the book is of general interest in an area of much relevance to modern fluid mechanics.

Laminar Flow Theory. By P. A. Lagerstrom. Princeton University Press, 1996. 268 pp. ISBN 0 691 02598 3. £15.95.

This book was first published as part of a collection of essays called *The Theory of Laminar Flows* by Princeton University Press in 1964. In that volume Lagerstrom was asked to provide the essential theoretical framework of laminar flows, with other contributors expanding on this material. The publishers have now chosen to re-issue Lagerstrom's essay without change, on the grounds that it is a "model piece of writing, and that it possesses the important qualities of brevity and clarity". It is hard to disagree. This is a beautifully written, succinct and insightful account of some of the basic concepts of fluid mechanics. Curiously, the original 1964 volume seems not to have been reviewed by *JFM*. One can only speculate that a reviewer at that time would have welcomed the emphasis on boundary layers, where Lagerstrom provides both physical insights and the mathematical precision of the (then newly developing) technique of matched asymptotic expansions. There can be no doubt that the original 1964 volume was quite influential in the development of the theory of boundary layers. More generally, the work of Lagerstrom and colleagues on the systematic use of inner and outer expansions has permeated much of fluid mechanics research in the intervening years. Of course, our knowledge and understanding of boundary layers in particular, and fluid mechanics in general, have increased enormously since this essay was written. Nevertheless, it has withstood the test of time, and can be recommended, both as an enjoyable piece of fluid mechanics reading, and as a concise and profound account of the fundamentals of our discipline.

Physical Processes and Chemical Reactions in Liquid Flows. Edited by F. R. Rys & A. Gyr. Balkema, 1998. 221 pp. ISBN 90 5410 700 6. 180 Hfl.

This monograph was produced under the auspices of the International Association for Hydraulics Research Section on Fluvial Hydraulics. It consists of 16 papers from different authors, some of a relatively introductory level, others research contributions. The subject matter is wide ranging with numerical, theoretical and experimental papers on mixing, chemical reactions in turbulent flow, formation of ice, flows in porous media, and drag reduction by polymers.

Continuum Mechanics via Problems and Exercises. Part I, Theory and Problems; Part II, Answers and Solutions. Edited by M. E. Eglit & D. H. Hodges (translated from Russian by A. N. Tiatiushkin). World Scientific, 1997. 270; 253 pp. ISBN 981 02 2546 6. £61.

These books were written by the Professors of the Department of Hydrodynamics at the M. V. Lomonov Moscow State University. They are intended for a (bright, mathematically inclined) undergraduate reader. The first volume is a lightning tour through theoretical continuum mechanics with chapters giving a reasonably critical treatment of tensors, kinematics, continuum equations, thermodynamics, discontinuities, Newtonian fluid dynamics (45 pages), elasticity, plasticity, electromagnetism and relativity, and dimensional analysis. There is a strong emphasis on problems for the student – more than 1000 in all – ranging from the straightforward to the sophisticated. Volume II gives the answers; solutions are sometimes a single line, sometimes a pithy paragraph. Those teaching undergraduate continuum mechanics courses will find plenty of useful examination ammunition here.

In Fascination of Fluid Dynamics. A Symposium in Honour of Leen van Wijngaarden. Edited by A. Biesheuvel & G. J. F. van Heijst. Kluwer, 1980. 501 pp. ISBN 0 7923 5078 2. 395 NLG or £135.

This book is reproduced from *Applied Scientific Research*, vol. 58 (1997/8), nos. 1–4. It contains 24 papers presented at a symposium held in honour of Professor Leen van Wijngaarden on his 65th birthday. The book begins with personal sketches of his life and scientific career by Zandbergen and Prosperetti respectively. There is then a series of contributions on topics in fluid mechanics with particular emphasis, appropriately for the dedicatee, on cavitation, bubble dynamics, bubbly liquids and fluidized beds.

Lattice-Gas Cellular Automata. By D. H. Rothman & S. Zaleski. Cambridge University Press, 1997. 297 pp. ISBN 0521 55201 X. £45.

Since the Navier–Stokes equations describe the flow of an enormous variety of physical systems, made of constituents with rather different shapes, sizes and interactions, one might hope that extremely simple interacting particle models might also be described in the same way. This has proven to be the case, and it is now possible to obtain numerical solutions of the Navier–Stokes system (as well as other partial differential equations) by simulations based on particles moving on a lattice and interacting via Boolean collision rules. This monograph is a fairly systematic survey of the lattice gas and lattice Boltzmann approach to fluid mechanics. Half of the text consists of an *ab initio* discussion of the models used and the physics and mathematics background needed to establish their properties, and a detailed derivation of the Euler and Navier–Stokes limits. In many cases, complementary intuitive and formal presentations are given, and the discussion is quite clear, if not always elementary. There is a somewhat brief discussion of applications to incompressible flow and passive tracer dispersion, and a lengthier treatment of more complicated models used for simulations of phase change and complex fluids. The question of the relative advantages of these methods with respect to other numerical approaches is not considered, and unfortunately there is little discussion of numerical accuracy. These omissions are particularly bothersome in the discussion of complex fluids, where it is easy to invent a model which segregates species in some way and produces pictures and numbers with perhaps some resemblance to observation. It is difficult to assess the physical relevance of such calculations, and it appears that the reader is being invited to play computer games.

Floating, Flowing, Flying. Pieter J. Zandbergen's Life as Innovator, Inspirator and Instigator in Numerical Fluid Dynamics. Edited by D. Dijkstra, B. J. Guerts, J. G. M. Kuerten & H. K. Kuiken. Kluwer, 1998. 253 pp. ISBN 0792 351282. £67.00.

This book is reprinted from the *Journal of Engineering Mathematics*, vol, 34, 1998, and is dedicated to Pieter J. Zandbergen on the occasion of his sixty-fifth birthday. It contains fourteen papers on disparate fluid dynamical topics (not particularly related to the title).

Experimentation, Modelling and Computation in Flow, Turbulence and Combustion, Volume 2. Edited by B. N. CHETVERUSHKIN, J. A. DÉSIDÉRI, Y. A. KUZNETSOV, K. A. MUZAFAROV, J. PÉRIAUX & O. PIRONNEAU. John Wiley & Sons, 1997. 280 pp. ISBN 0 471 95849 2. £75.00.

This volume contains the lectures delivered by French, Russian and Uzbek scientists at a Workshop in Uzbekistan in 1995. As noted in this Journal in connection with volume 1 (*J. Fluid Mech.* vol. 319, 1996, p. 412) the contributions are too varied and specialized to allow a useful description.