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REVIEWS

Hydrodynamic Stability. By P. G. DRAZIN and W. H. REID. Cambridge University Press, 1981. 525 pp. £35 (hardback).

Each of the distinguished authors of this long book has extensive experience of several aspects of hydrodynamic stability, although their contributions to the subject have come from rather different points of view. The reader naturally approaches their work with pleasure. What sort of book have they combined to write? What is the *level*? What is the *nature* of the treatment? Does the book contain a coherent and balanced account of the subject.

Before considering these various questions, I would like to make some preliminary remarks. This book is certainly a graduate text, and the discussions of several important topics are given with detail and clarity, in a way that many graduate students and lecturers will find both appropriate and helpful. Moreover, its value is enhanced by a nice collection of problems, not always easy to find in this subject, and by a supplementary booklet of 'Solutions to the Problems', produced by the authors themselves and not by the Cambridge University Press. For these reasons and for its broad view of the subject, it is, I think, a better book to use for graduate study in 1982 than any possible competitor, namely the books of Lin, Chandrasekhar, Betchov & Criminale, and Joseph, though each of those texts has its own special niche. The present book is a creditable achievement. But I think it a pity that the Press has lessened its sales prospects by pricing the hardbacked edition at £35 Sterling.

Given the price, and the likely impact of this on graduate students as prospective purchasers, the reader naturally asks if he would get value for money. And here, I think, I must sound a note of disquiet. There are several places where quite important topics have been omitted or treated too briefly. There are several instances where the authors give, I believe, an inappropriate assessment. A lecturer for a graduate course in hydrodynamic stability will need to amplify and modify in places the treatment given in Drazin and Reid's book.

Bearing the above general assessment in mind, I would like to devote most of the remainder of this review to a more detailed examination of the chapters and sections of this book. It is instructive to list the titles and number of pages of the chapters: 1, 'Introduction', 26 pages; 2, 'Thermal instability', 32 pages; 3, 'Centrifugal instability', 53 pages; 4 (i), 'Parallel shear flows, The inviscid theory', 22 pages; 4 (ii), 'Parallel shear flows, The viscous theory', 93 pages; 5, 'Parallel shear flows, Uniform asymptotic approximations', 67 pages; 6, 'Additional topics in linear stability theory', 44 pages; 7, 'Nonlinear stability', 89 pages; Appendix, 'A class of generalized Airy functions', 14 pages.

The lengthy account of linear viscous theory and its ramifications, to which 174 pages are devoted, gives a thorough discussion of the classical asymptotic methods for the Orr–Sommerfeld equation. However, I believe that excessive space has been given to some aspects of that subject in this day and age, especially in view of topics omitted. Much elegant mathematics has been done, not least by Professor Reid, and much of the detail, in research-paper form, is presented here. This work has given, to very high accuracy, the neutral curve for plane Poiseuille flow. However, it has not the same central importance as the work of Heisenberg, Prandtl, Tollmien and their successors, in showing the phase-shifting *mechanism* by which viscosity can produce instability. Furthermore, to the uninitiated reader, the balance of the discussion may give an unintended impression. It is unfortunate that the work of F. T. Smith (1979), showing the power of the triple-deck method and related developments, is barely mentioned, perhaps because it appeared just a few months before this book was finalized. I believe that a discussion of triple and higher-order decks would have brought home the formidable achievements of our distinguished predecessors of the 1920s, who were perforce limited to less satisfactory asymptotics.

There are curious omissions and comments in the sections on viscous instability theory, and its comparison with experiment. (i) In the discussion of the asymptotic-suction profile, for example, it is not recorded that Grohne (in 1950) and Baldwin, who repeated the work some years later, have shown that the Orr–Sommerfeld equation for this case has an exact, though complicated, analytical solution. (ii) For a comparison between theory and experiment for Blasius flow, it is naturally important to recognise the importance of the non-parallel nature of the flow, in contrast with the parallel-flow assumption made in much of the theory. Contributions to this problem have been made by several authors, and the reader is advised of two papers which 'would appear to be . . . the most successful theories'. Unfortunately, however, they do not point out that, in a comparison of a non-parallel theory with observation, it is essential to specify the *particular* quantity being calculated *and* its location in the boundary layer; in fact, as Gaster's powerful contribution of 1974 makes clear, the neutral curve near to the critical Reynolds number depends crucially upon this choice, which it does not in the parallel-flow theory. 'The most successful theories', to which the reader's attention is specifically drawn, did not apparently make appropriate comparisons, and I question the wisdom of relying on 'remarkably good agreement with experiment', in advance of self-consistency of the theory. Although the authors do recognise that 'some points remain obscure or controversial', I believe that they might well have highlighted rather the stimulating contributions of Gaster (1974) and F. T. Smith (1979). While Gaster used a WKBJ method with an anomaly, in that some $O(\epsilon)$ terms are necessarily required at $O(\epsilon^0)$, and thereby obtained a critical Reynolds number, Smith showed how a rational calculation can be done on the upper and lower branches of the neutral curve by triple-deck methods and developments. These two approaches complement each other.

Earlier in the book the authors disturb the stability of our equilibrium somewhat over the use of the terms 'neutral' and 'marginal', since they define the former to refer to a mode of zero growth rate which is not necessarily in a neighbourhood of amplified modes, while the latter term is defined as the case when the mode of zero growth rate *is* embedded in such a neighbourhood. Somehow, I doubt if conventional usage will be changed, in which 'neutral' refers to a boundary between damped and amplified perturbations!

Thermal (buoyancy) and centrifugal instabilities are treated clearly and in reasonable detail, though I regret (as may chemical engineers also) the absence of any discussion of surface-tension and Marangoni instabilities, though Pearson and Block, but not Scriven, are mentioned. Pearson's paper of 1958 is surely a classic worthy of better than this! At least one other novel development of recent times, namely the theoretical and experimental demonstrations by Seminara and Hall of centrifugal instability generating toroidal vortices in the Stokes layer of a torsionally oscillating circular cylinder, has been ignored completely.

The chapter labelled as 'Additional Topics' gives discussions of stratified-flow and baroclinic instabilities, the MHD pinch instability, the Gaster transformation for spatially growing waves, and the instability of unsteady basic flows. I wish these topics could have been treated in greater detail; for example, explicit detailed reference is not made to Professor Drazin's own significant research papers on baroclinic instability, a case, perhaps, of undue modesty. The section on unsteady flows leans heavily on Ursell and Benjamin's pioneering and beautiful work on the Mathieu instability of a free surface in vertical oscillation. This is a special problem, but one whose connection with generally accelerating interfaces, and with the Rayleigh–Taylor instability of *uniformly* accelerating interfaces, is not made clear. Reference is made to the broader class of instabilities of unsteady flows with shear, but no mention is made of important work by Hall on the stability of the Stokes layer on a flat oscillating plane, where it is now known that a discrete spectrum of oscillations bifurcates out of the continuous spectrum at certain Reynolds numbers and wavenumbers.

The final chapter concerns 'Nonlinear Stability' and covers a lot of material, taken from many corners of the subject. I am pleased to see that the pioneering work of W. V. R. Malkus (1954, 1958), and of his colleague, G. Veronis, is given a rather more sympathetic reporting than was the case in Joseph's book. But even so, their work is insufficiently appreciated here. The present account rightly stresses the important seminal contribution of the great theoretical physicist Landau (1944), but the plain fact is that this paper did not show how an amplitude equation could be inferred from the Navier–Stokes or, indeed, any other partial differential equations. This understanding came in the late 1950s and early 1960s, but the approach in the present volume suggests that the work of Malkus and Veronis, and of Gorkov, on nonlinear equilibria, was, in comparison with Landau's unique paper, a mere calculation. It seems that Professors Drazin and Reid show a lack of sympathy with the crucial breakthrough made by Malkus, Veronis and others in the late 1950s and early 1960s, this being reflected in an inadequate treatment of perturbation methods in this book.

Instead of giving any such treatment for a real shear-flow problem (as opposed to a model problem), the authors go on to treat resonant interactions in water waves, and this partly by reference to N. Rott's work on double pendula. This treatment appears out of the blue, since the Stokes wave and pendulum dynamics have not appeared in detail earlier in the book. This chapter is, indeed, enlivened by many such excursions into different facets of the subject, but at the expense of a coherent and logical account of what are the firm methods and results of theory and experiment, in relation to the central theme of nonlinear instabilities in shear flows. There is but one illustrated comparison between theory and experiment shown in this chapter, namely between the experiments of Donnelly and the theory of DiPrima and Eagles for torque in rotating cylinder flows. I regret the absence of illustrations of the beautiful experimental results of, for example, Klebanoff, Gaster, Benjamin, Levchenko, Nishioka and their coworkers for flows in boundary layers, between rotating cylinders and in pipes and channels. In particular, the importance is not made clear of Nishioka's work in establishing experimentally the reality of the phenomenon of a threshold amplitude in shear flow instability, so long expected on theoretical grounds.

To return to my earlier rhetorical questions, I cannot agree that, as well as being suitable for a graduate course, this book 'also leads the reader up to the frontiers of research on selected topics', at least in areas of significant development at the present time; this book is, I believe, firmly a graduate text and not a research monograph. I have not found the relationship of 'theory to experimental . . . results' to be at all satisfactory; the strength of this book is decidely in the use of applied mathematical analysis.

Finally, I find this book to be remarkably unbalanced in its selection of topics and in the allocation of space to those chosen. For these reasons, I believe that this book should be used as a graduate text only with caution and guidance. Even so, many parts of the work will be found valuable by practitioners of the subject, and it is good news that the Press are already producing a much cheaper paperback version.

J. T. STUART

SHORTER NOTICES

Two-Phase Flow Dynamics. Edited by A. E. BERGLES and S. ISHIGAI. Hemisphere, 1981. 554 pp. $75.00.

The flow and heat-transfer properties of gas–liquid mixtures have been studied extensively in recent years, the major stimulus being the need to develop predictive analytical models of the behaviour of water-cooled nuclear reactor systems and liquid-metal-cooled fast breeder reactor systems following some accidental sudden change of the operating conditions. Many of the papers presented at the Japan–U.S. Seminar on Two-Phase Flow Dynamics and recorded in this volume have a review character, and the volume as a whole gives a view of the present state of knowledge of gas–liquid flow systems. The particular choice of participants, most of whom were from Japan, has led to an emphasis on the engineering and 'operational' aspects in this book. There is much useful practical information here, although there will be some readers who yearn for clear discussion of the justification for the many 'model' equations introduced by authors.

Microemulsions. Edited by I. D. ROBB. Plenum, 1982. 259 pp. $35.00.

A microemulsion is a thermodynamically stable intimate mixture of at least two fluids, typically water and oil, which are not miscible on the molecular scale. An essential ingredient is a surfactant which lowers the surface tension between two of the fluid phases. The dispersed phase may be in the form of clearly defined spherical drops, or it may have so complicated a structure that the distinction between dispersed and continuous phases is lost. The low viscosity of microemulsions and their low surface tension against oil make them particularly suitable for use in the 'tertiary phase' of recovery of oil from porous rock reservoirs. This volume records the texts of 15 papers presented at a two-day conference on the 'Physical chemistry of microemulsions' organized by the Chemical Society (of U.K.) in September 1980. The emphasis is (understandably) on the structure and physical chemistry of microemulsions rather than their dynamical properties.

Radiation Heat Transfer Notes. By D. K. EDWARDS. Hemisphere, 1981. 370 pp. $19.95.

This modest but workmanlike volume is intended for use with a 40-lecture course on radiative heat transfer for engineering students. About half the book is about transfer between surfaces of different kinds, and the other half is concerned with radiation within an absorbing gas. Lots of exercises are provided at the end of each of the eight chapters. The text is reproduced from camera-ready typescript and the covers are flexible, but the book can be read and handled easily. It looks like a good buy for students.

Advances in Solution Chemistry. Edited by I. Bertini, L. Lunazzi & A. Dei. Plenum, 1981. 387 pp. $49.50.

This is a record of a number of the lectures given at the 5th International Symposium on Solute–Solute–Solvent Interactions held at Florence in June 1980. One or two of the papers are concerned with basic aspects of the structure of liquids, but the great majority of the 26 papers are on specialized topics in physical, organic and inorganic chemistry. Not a book for the uninitiated.

Heat Exchangers. Edited by S. Kakac, A. E. Bergles & F. Mayinger. Hemisphere, 1981. 1131 pp. $95.00.

A NATO Advanced Study Institute on 'Heat exchangers: Thermal–hydraulic fundamentals and design' was held at Istanbul in Auguest 1980, and we find here the edited texts of 16 invited lectures and of a number of research reports. NATO Advanced Study Institutes have a didactic function as well as providing a forum for the discussion of recent research, and this volume is accordingly more expository than the usual conference proceedings. Papers are grouped under the following headings: Introduction (2); Thermal–hydraulic fundamentals: single-phase (8), two-phase (7); Radiative heat transfer in heat exchangers (1); Heat-exchanger design: rating, sizing, and optimization (17); Advanced surface selection and performance (4); Operational considerations (9); Problems and prospects for the future (2). The subject matter is mostly rather technical and close to engineering practice, although there is also the odd paper which raises interesting scientific questions, such as the one by B. I. Kilkis on fluidized-bed heat exchangers. The book has been reproduced from camera-ready typescript, and the type is mostly too small and faint for this reviewer's comfort.

A Further Compilation of Compressible Boundary Layer Data with a Survey of Turbulence Data. By H. H. Fernholz and P. J. Finley. AGARD-AG-263, published by NATO, 1981. 222 pp.

This commissioned report, which is more interesting than the title suggests, is a continuation of *AGARDographs* 223 (1977) and 253 (1980) by the same authors and presents data on a further 18 two-dimensional boundary layers, some of which involve shock–boundary-layer interaction. There are 65 pages of useful description of turbulent compressible boundary layers, methods of measurement, and comment on the available data, followed by sets of data in tabular and graphical form, on a common basis, for the 18 boundary layers. Much of the data comes from government laboratories. Copies of the report are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.