J. Fluid Mech. (1992), *vol.* 242, *pp.* 721–725
Printed in Great Britain

REVIEWS

Computational Methods in Viscous Aerodynamics. Edited by T. K. S. MURTHY and C. A. BREBBIA. Elsevier, 1990. 370 pp. $133.25 or Dfl. 260.

Numerical treatment of inviscid compressible fluids is probably the most prominent recent success story of computational fluid dynamics. A whole host of techniques – TVD schemes, flux limiters, Taylor–Galerkin and Lagrange–Galerkin methods, particle schemes, etc. – that have emerged in the last decade can be used to solve, say, the Euler equations. The task in hand can be done both safely (correctly resolving shocks and rarefaction fans, producing the right asymptotics) and relatively cheaply, and it is underpinned by powerful theory.

Viscous flows present more of a challenge, and the results to date are considerably more modest. However, as both computing machinery and the confidence and skills of CFD professionals become more formidable, it is only natural for three-dimensional Navier–Stokes equations, in their full glory, to be subjected to a numerical approach. This is the theme of the Murthy–Brebbia compilation, that brings together ten tutorials, reviews and case stories.

It is in the nature of such a diverse publication that the material extends from the very basic all the way to research level and that it covers a wide variety of techniques. However, several strands run through the book and, indeed, through much of the ongoing research on its subject matter.

Firstly, velocity–vorticity formulation is the standard – not because it is necessarily more informative than the use of primitive variables, but since it leads to the important economy of reducing the space dimension.

Secondly, simple well-tried discretization methods are the order of the day – either finite differences or Galerkin. This, of course, has the virtue of simplicity. Unfortunately, little attention is paid to the more 'exotic' methods that have been the focus of intense research in the last decade, like spectral and pseudospectral techniques, boundary-element methods, particle methods, etc. The absence of boundary-element methods is, probably, the most disappointing, since the latter confer all the advantages of the velocity–vorticity formulation (namely reduction in dimensionality), while being accompanied by considerably more profound theoretical understanding.

Thirdly, at the end of the day, the lion's share of the computational effort must be expended on solving algebraic problems. This point is rightly emphasized throughout the volume. The many computational methods for algebraic (linear and nonlinear) problems therein are a mixed bag – alongside the highly effective multigrid and conjugate gradient techniques, much space is devoted to 'direct' techniques, a euphemism for the relatively wasteful Gaussian elimination. No mention at all of Fourier transform techniques or of preconditioned conjugate gradients....

Vector, systolic and parallel architectures have an obvious impact on number-crunching, by dint of leading to considerably more powerful computers. However, the influence of parallelism on the numerical thinking is both more subtle and more profound than simply giving more bang for the bucks. The standard algorithms in the numerical arsenal have been developed with the serial architecture of the von Neumann machine in mind. As such, they may yield themselves poorly to parallelization. If the early approach to parallel computers centred on 'parallelizing' existing algorithms, the more recent focus is on developing purpose-built methods that take full advantage of specific parallel architectures. There are many echoes of this more modern approach throughout the volume. An interesting example is in the paper of Gunzburger *et al.*, who consider a finite-element method which requires the solution of six uncoupled Poisson equations at each step. This, obviously, can be done in parallel.

As already mentioned, the knowledge transfer from the numerical to the CFD community leaves much to be desired. Of course, transient enthusiasms of numerical mathematicians frequently deserve a dose of healthy scepticism. But occasionally the attempts of numerical analysts meet with success, and this should be more widely known among their 'clients'. Besides boundary elements and preconditioned conjugate gradients, I have also sorely missed a reference to the Greengard–Rokhlin multipole methods for the Poisson equation. Likewise, although dimensional splitting is repeatedly (and rightly) mentioned, it is always the Beam–Warming splitting, which is of the lowest order compatible with consistency. Other forms of dimensional splitting (due for example to Strang and to LeVeque and Oliger) are considerably more accurate, while not adding significantly to computational expense, and they parallelize well.

To sum up, this is a useful volume and it presents a wide range of well-tried techniques. However, numerical solution of large and difficult problems calls for the most powerful tools available. This means, in practical terms, that the fluid dynamicist and the numerical analyst need to tread more often the path to each other's office.

A. ISERLES

Magnéto-hydrodynamique. By R. BERTON. Masson, 1991. 253 pp. FF 330.

There are very few books which attempt to cover the entire range of magnetohydrodynamic (MHD) phenomena from engineering to astrophysics, and this new publication is welcome. It is not an elementary textbook, but neither is it technically complex. The reader is led very rapidly to the forefronts of many different research areas, in which key papers are chosen to act as backbone of the discussion. These are summarized somewhat concisely, which can at times be disorientating. As the subject matter progresses, equations and illustrations may catch the reader unawares, although the gist is usually clear, even in relatively unfamiliar areas.

After a brief introduction to the equations of MHD, various applications are considered, grouped into seven sections: electricity generation, propulsion, pumps, the metallurgical industry, solar physics, terrestrial magnetism and the dynamo effect. The author's own speciality is solar physics, and this is discernible from the presentation, although not excessively. Naturally, each of these topics could form the subject of an entire book, and it is a formidable task to capture the background and key results of each in a single chapter. In this the author is on the whole successful, despite inevitable gaps. A certain amount of pre-knowledge is sometimes necessary in order to keep track of the discussion. For clarification and detail the reader is directed to suitable references, which include the classical and some of the more recent. Inevitably there are omissions from these – there seems to be a bias towards west European publications. Somewhat surprisingly, I was unable to find a single reference to the MHD group at Riga, or to the journal *Magnitnaya Gidrodinamika*.

The book is readily comprehensible to those with reasonable school-level French. The technical vocabulary is fairly similar to English, while the structure of sentences follows familiar scientific patterns, based as it is around equations. I do not think that those who contemplate acquiring this book are likely to have significant language problems.

In conclusion, this book would be a useful possession for those with either a general or more specialized interest in MHD and its applications. It is neither exhaustive nor definitive, but it provides a state-of-the-art overview of a wide variety of research areas, and should be of interest to mathematician, engineer and physicist alike.

A. J. MESTEL

Meteorological Fluid Dynamics. By R. K. ZEYTOUNIAN. Springer, 1991. 348 pp. $36.

Asymptotic Modelling of Atmospheric Flows. By R. K. ZEYTOUNIAN. Springer, 1990. 396 pp. $98.

Geophysical fluid dynamics is a fairly coherent branch of fluid mechanics, comprising work on stratified fluid, flow relative to a rotating frame, convection, and magnetohydrodynamics fundamental to meteorology, oceanography and geology. It is now a mature subject, although its geological parts are still being developed rapidly (for example, the importance of compositional convection in driving the Earth's liquid core was generally accepted only in the 1980s). It is a subject covered by many books, some of which have been favourably reviewed in this *Journal*. My favourite for general coverage of meteorology and oceanography is Gill's *Atmosphere-Ocean Dynamics* (Academic, 1982) but there is still a need of more good textbooks for lecture courses and of monographs on selected specialized topics for research. These two books address the need.

The former is a textbook on the mathematical theory of waves and instability in meteorology (and so in oceanography too). It could serve well for a graduate course, although it devotes little space to the relationship of its theoretical results to meteorological applications and it has no worked examples or exercises for students. It covers the equations of motion, the f- and β-planes, internal gravity waves, Rossby waves, the Boussinesq and geostrophic approximations, lee waves, Ekman layers, the triple-deck method, baroclinic and barotropic instabilities of parallel flows, Kelvin–Helmholtz instability, Rayleigh–Bénard instability, and the Lorenz system and chaos, with brief excursions on solitary waves and the fractal structure of turbulence. This seems to me to be a well-balanced selection of topics in the field chosen by the author, although there are no Taylor columns, Stewartson layers, shallow-water approximation, tidal waves, Palm–Eliassen fluxes, critical layers, or double-diffusive convection. The approach is rather mathematical, with emphasis on asymptotics rather than problem solving or physical interpretation, but it will suit many. The author asks for the indulgence of English-speaking readers, 'thinking that they might prefer a text in not quite perfect English rather than in "perfect" French'. Certainly the camera-ready copy produced by the author is a little rough and has many minor failings, but the book is in a series of Lecture Notes in Physics, and many readers may prefer it to be inexpensive rather than polished.

The author claims that the former of the two books also 'is a good preparation for the reading of [the] latter', although the latter was in fact published a little earlier. The latter is a monograph, translated from the French by a professional and printed in the usual way. The translation is nevertheless often infelicitous (I reached for a dictionary to confirm that 'unicity' and 'versant' are, indeed, English words and that 'non-consistent' is not), and the editing poor (misspellings, misprints, no running titles). Should we be asked to pay so much for these services? Perhaps not, but the book will nevertheless be good value if the material is excellent. Is it?

The author acknowledges that dynamic meteorology is too large a subject for him to attempt to cover completely. He 'has set forth what are, for the most part, his own results' in accord with his 'conception of meteorology as a fluid mechanics discipline which is in a privileged area for the application of singular perturbation techniques'. He applies the method of multiple scales or the method of matched asymptotic expansions to any equations he can find, systematically reviewing his own and his associates' extensive research. So it is a very personal view of meteorology, covering some areas of geophysical fluid dynamics with a formidable battery of notation. The nature of the subject demands a large and complex notation in any rational treatment (as in Pedlosky's *Geophysical Fluid Dynamics*, Springer, 1979). But the notation will allow only a few to benefit from this book. It is a barrier which I found hard to cross, not having the time and will to work through the book line by line; as a result work with which I am familiar was difficult for me to follow.

The approximations of dynamic meteorology are mostly singular. Nonetheless, their essentials are well understood by meteorologists now, albeit in a rough and ready way, and meteorologists are unlikely to be influenced by Zeytounian's approach. Yet the approximations of meteorology are subtle and deserve a more rational development than is commonly understood. This is the achievement of the book. The author derives many equations systematically, albeit not rigorously, from the primitive equations rather than solves equations governing particular problems. For all these reasons, I feel that the book will be studied intensively by a few specialists but neglected by others.

P. G. DRAZIN

Interfacial Transport Processes and Rheology. By D. A. EDWARDS, H. BRENNER and D. T. WASAN. Butterworth-Heinemann, 1991. 558pp. £60.

Interfacial Transport Phenomena. BY J. C. SLATTERY. Springer, 1990. 1159pp. DM 168.

These two books cover much the same ground. Both are presented as for a graduate student course in Chemical Engineering, with plenty of worked and unworked examples; they probably originated as lecture courses. Both are very firmly based in a continuum representation of bulk and interfacial phenomena and apart from pictorial reference to surfactant molecules (with hydrophobic/hydrophilic extremities) in Edwards, Brenner & Wasan (E, B & W), there is no discussion of molecular behaviour as such. Both are formal in the best mathematical sense, with careful attention to geometrical description; both emphasize the importance of experiments to derive necessary constitutive relations. They are well researched with numerous well-chosen references to earlier work. The typography in both leaves a little to be desired, but the use of camera-ready copy by the printer probably makes the books cheaper than they would otherwise be.

Of the two, I prefer E, B & W. Indeed I like it very much. That is largely because I am very much in sympathy with their general approach (common to the authors of both books) to formulating problems in continum mechanics, an approach which forms a satisfactory basis for far more elaborate theories and applications than they can explain in detail in their texts. The more pragmatic approach of many successful workers tackling specific problems is often easier to grasp in the earlier stages of learning, but requires a process of unlearning and relearning as more detailed approaches are required for more complex problems.

To carry off this general approach requires very careful organization of the material presented, and great care in linking the formal parts to the experimental observations, simple problems and seminal applications. It is at this level that E, B & W are the more successful. Each chapter is complete in itself and yet each forms part of a well-connected whole. Multi-author texts sometimes suffer from fragmentation: in this case each of the three authors has clearly written his share with the whole text in mind: I suspect each has helped remove ambiguities or weaknesses in the others' contributions. By contrast, Slattery's account contains some repetitions and disjointness that makes the going rather laboured, though any author who can sustain a consistent approach for over a thousand pages deserves great credit.

E, B & W devote the first two chapters to a basic introduction covering the whole field in familiar physicochemical fashion without any but well-understood mathematical relations. The next three chapters derive the conservation equations of mass, momentum and energy in the bulk (three-dimensional) and interface (two-dimensional) continua, showing how the latter act as boundary conditions to the former. The scope of constitutive behaviour in the interface is well covered in properly tensorial fashion, and specific non-Newtonian and viscoelastic models are introduced. The formality is leavened by reference to observation and simple applications. The solutions obtained are used in later chapters. The next four chapters cover measuring devices: those at all familiar with these techniques will know that very careful analysis of boundary-value problems is required to extract the required constitutive behaviour. Chapters 10–14 are for me the justification for writing and reading the text. They cover interfacial stability, thin liquid film hydrodynamics and stability, and emulsion and foam stability, and address the main technological issues involved. If anything these chapters are too short and leave the serious worker with a lot of reading to do before having a comprehensive up-to-date insight into the matters touched upon – the authors clearly do not believe in reporting much speculative or unsubstantiated work.

Part II of E, B & W on the micromechanical theory of interfacial transport processes occupies a quarter of the book and shows how perturbation theory applied to a fully three-dimensional treatment leads, in the limit, to a lower-dimensional interfacial representation. This part stands satisfactorily on its own and is undertaken in perhaps excessive detail: there are several places where the single word 'similarly' might have replaced a page of derivation.

A list of the seven chapters in Slattery's book might suggest that he is only concerned with establishing the foundations of the subject as a companion volume to Truesdell & Noll's *The Non-linear Field Theories of Mechanics*. Although the formal approach is indeed based on the earlier text, Slattery does however devote a substantial part of his writing to experimental observations and applications. These are interspersed among the formal development and include a wider range of observations than E, B & W. His approach is less tightly consistent, in that some of the more difficult issues are discussed in a fashion that makes little or no use of the complex formality that is at the heart of the book. However, on my test subject of the moving contact line over a solid surface, he has much more to say than E, B & W. Unfortunately I do not think that he gets to the root of the matter in mathematical terms; there is no discussion of intermediate asymptotics, and so the subject is left curiously unresolved; he does give a critique of the references available, but I think underestimates the depth of understanding achieved by Dussan.

These two books are to be welcomed and should serve to draw together workers of various backgrounds by showing how forbidding mathematical formalisms can help to provide quantitative explanations of otherwise mysterious phenomena in interfacial science.

J. R. A. Pearson