J. Fluid Mech. (1982), *vol.* 114, *pp.* 529–534
Printed in Great Britain

REVIEWS

Dynamics of the Upper Atmosphere. By Susumo Kato. D. Reidel Publishing Company, 1980. 233 pp. $29.95.

This book launches a new series of monographs on 'Developments in Earth and Planetary Sciences' which has a predominantly Japanese Editorial Board with Professor T. Rikitake as Editor. The series is intended to stress Japanese work, and the extent of Japanese involvement in the geosciences promises a valuable series of publications to come.

The 1950s saw the start of a new era of observational research in the Earth and planetary sciences which was greatly stimulated by the I.G.Y. 1958 and subsequent international programmes. In the following two decades, our knowledge of the upper atmosphere advanced spectacularly through the introduction of research rockets and satellites, high-speed computers and high-powered radars. At the same time, observational results set challenging problems for theoretical investigation, particularly in the realm of dynamics of the upper atmosphere. Japan, in particular, has been notable for its theoretical contributors to geomagnetism and ionospheric dynamics; and amongst these is Susumo Kato, the author of this book, who has made important contributions to the theory of atmospheric tides and that of the ionospheric dynamo.

The book begins with a concise (12-page) general introduction on atmospheric structure and the fundamental atmospheric relations and equations of motion. The main text offers what is described as a 'mathematically oriented introduction to the dynamics of the Earth's upper atmosphere, with special emphasis on acoustic-gravity and tidal waves and their ionospheric effects'. There are four chapters after the general introduction: one on acoustic-gravity waves, a long chapter (exceeding a third of the length of the whole book) on atmospheric tides and two shorter ones on electrodynamics of the upper atmosphere and the tidal dynamo. This is a good arrangement. The Coriolis force is neglected in chapter 2, but needs to be retained in chapter 3 as tidal frequencies are equal to or are simple multiples of the rate of rotation of the Earth; and in chapter 3 horizontal wavelength scales require a formulation with spherical geometry: chapter 4 together with key results from chapter 3 prepares the ground for chapter 5 on the tidal dynamo.

Chapter 2 launches straight into acoustic-gravity wave theory, referencing the well-known 1960 paper of Hines and leading to the classification of frequency ranges for acoustic, evanescent and gravity waves. Work of the author on solutions for line and point sources from Kato *et al.* (1977) then follows and the chapter ends with a valuable section on observed AGWs. At this point the reader sees that the problem of observing the characteristics of the three-dimensional time-dependent phenomenon of atmospheric waves, although difficult, is not entirely impossible: in fact it was through observations in the 1950s at ionospheric heights that the importance of the gravity-wave mechanism became generally recognized.

In chapter 3 a detailed account of classical tidal theory is included 'due both to its continuing relevance today and its value as a mathematical training for students'. With diagrams and tables the account extends to 40 pages and much of it follows the original formulation of Hough (1898). One shortcoming here is that in spite of the length of the presentation the reader is not informed of later treatments, such as that given by Dikki (1965), which uses fully normalized associated Legendre functions. The following sections of this chapter present good, up-to-date reviews on 'Recent developments in tidal theory' and 'Tidal observations'. Chapter 4 brings the reader to ionospheric levels and considerations of the interactions between charged particles and neutrals in the weakly ionized atmosphere through collisions and the presence of an electric field. This chapter encompasses the motion of charged particles in a weakly ionized moving gas, the associated electric field, the three conductivities and the ionospheric phenomena of equatorial and auroral electrojets and sporadic-E: it neatly combines theory and observation. Tidal dynamo theory has its origins in the work of Martyn & Baker (1953) and the early desire to interpret global ground-based daily magnetic variations in terms of ionospheric S_q current systems. Chapter 5 then rather briefly reviews developments from the mid-1960s when the newly discovered (1, −2) mode of the solar tide was shown to be relevant to the S_q variation. The chapter ends by returning to theoretical aspects and presents recent solutions (Kato & Tsuda 1980) to the three-dimensional dynamo problem which it is considered are needed in place of conventional theory, where a height-integrated current is employed, if better agreement with observation is to be obtained.

Much of the material in the book, it is stated, was first presented in a graduate course that the author taught in 1973–4; and its study could be recommended as an introduction to upper atmosphere research. Each of the four main chapters follows the pattern of dealing first with established theory and then turns to the research scene as depicted by results, often of an experimental nature, selected from papers published in recent years. The need in scientific investigation is demonstrated for a close association between observation and theory, the aim being to successfully model by mathematical formulation and computation the observational results. The account of the work of Roble *et al.* (1978) on the modelling of a travelling ionospheric disturbance (TID) is a good example of what might be achieved. So also is that of Schieldge *et al.* (1973) who attempted a simulation of the equatorial electrojet as well as the global S_q current system on the basis of four tidal modes, whose amplitudes and phases were varied from day to day to explain the observed S_q variation. When purely theoretical analysis becomes intractable, high-speed computers are able to extend the investigation numerically and allow more detailed physical effects to be handled. This is particularly evident in the work on tides where, with the introduction of viscous damping and mean zonal winds and temperature gradients in the background atmosphere, a 'variable separable' solution is no longer possible. The work and numerical results of Lindzen & Hong (1974) on semi-diurnal tides and of Forbes & Garrett (1976, 1978) on diurnal tides in the thermosphere well illustrate the scientific value of the 'number-bashing' technique.

The scope of *Dynamics of the upper atmosphere* is somewhat less than its title 'atmospheric waves and their effects on the upper atmosphere' might indicate. Topics such as atmospheric circulation, turbulence and nonlinear effects are not included; and planetary waves and wave–mean-flow interaction receive little more than a mention. Also the subject of the lunar tide is not included which is surprising, because although its magnitude is much smaller than that of the solar tide it falls within the general theme of the book.

Wave propagation in the real atmosphere is an active research area, and current developments make the appearance of this review monograph a timely event. The author combines in one text material on basic theory and traditional developments with results from areas of current research. Original sources are well referenced and a good insight may be gained into the respective contributions (and limitations) of theory and observation and into the chronological development of the topics considered.

GERALD V. GROVES

An Introduction to the Physical Properties of Large Molecules in Solution. By E. G. Richards. Cambridge University Press, 1980. 266 pp. £18.00 (hardback).

This volume is one of a series promoted by the International Union of Pure and Applied Biophysics and intended as a textbook for final-year science undergraduates and graduate students. It is described accurately on the dust sheet as providing 'a basic introduction to the concepts used in the description of the properties of large molecules in solution' with emphasis on 'definitions and the physical meaning of the concepts discussed, rather than mathematical rigour or detail'. The range of topics included under the title is broad, but the author has organized the material well. Early chapters discuss the basic physics of macromolecules and interactions between them, and subsequent sections are concerned with the equilibrium thermodynamics of macromolecular solutions; the statistical mechanics of linear polymers including helix-coil transitions; polymer gels; the hydrodynamic properties of macromolecules; and the special features of polyelectrolytes. An additional chapter by S. D. Dover gives a theoretical account of the observational techniques of light, X-ray and neutron scattering by large molecules.

The expository style of the text is clear, and the author fulfils his aim of providing a physical 'feel' for many of the jargon terms of the subject. Very little specialist knowledge is expected of the reader, but the price for this is paid in terms of the space taken in defining standard terms (for example, *flux*) when they are first needed. In addition, because the mathematical background assumed is especially slight, some explanations, whose mathematical expression would occupy just a few lines, run to several pages of written argument (as, for instance, the four-page discussion of multipole interactions between charged molecules) and their underlying simplicity is obscured.

It is inevitable under such circumstances that much of the coverage will be superficial and in consequence will not bear detailed investigation. This point is best illustrated by reference to the chapter on the hydrodynamics of macromolecular solutions which is perhaps of greatest interest to readers of this Journal. The chapter deals mainly with the topics of sedimentation, diffusion and viscosity (at infinite dilution) and provides a descriptive account of Brownian motion, low-Reynolds-number hydrodynamics and suspension mechanics, but the details of the account leave much to be desired. First, for instance, viscosity is discussed entirely in terms of simple shear flows; extensional flows – in which polymer solutions behave most dramatically – are considered not to exist. Second, in treating the additional (Einstein) viscosity in a dilute suspension of rigid spheres it is suggested that the rotation of the spheres in the shear is responsible for the extra energy dissipation: in fact the *rotation* dissipates no energy, the failure of the particles to *strain* with the fluid causes the extra disturbance. Third, the description of the zero-shear-rate intrinsic viscosity of a suspension of spheroids undergoing thermal agitation makes no mention of the direct contribution of the Brownian motion to the stress, and quotes results by Simha, which have now been superseded by the work of Giesekus (1962, *Rheologica Acta* 2) and others, so that the tables and graphs are incorrect.

The author has performed a useful service by gathering together the physical principles which underlie a wide range of macromolecular phenomena. The book's synoptic approach does not, as the examples above illustrate, always bear close scrutiny, but does serve as a readable introduction to more specialized texts.

J. M. RALLISON

Mixing in Inland and Coastal Waters. By HUGO B. FISCHER, E. JOHN LIST, ROBERT C. Y. KOH, JÖRG IMBERGER and NORMAN H. BROOKS. Academic Press, 1979. 483 pp. $35.00.

This book is an outgrowth of research contributions by the authors at the University of California, Berkeley, and at the California Institute of Technology, during the past twenty years.

The first four chapters treat the basic concepts of Fickian diffusion, turbulent diffusion and shear flow dispersion. There is a straightforward derivation of Fickian diffusion in one, two and three spatial dimensions. Combined advective and diffusive processes are treated only briefly. The important boundary-layer-type approximation (i.e. the conditions under which it is permissible to neglect diffusion in the direction of advection) receives scant attention.

The chapter on turbulent diffusion introduces the necessary statistical concepts and concludes with a useful summary of the limitations of the Fickian equation in turbulent mixing. This leads to a discussion of shear flow dispersion, following the classical Taylor development, for laminar and turbulent dispersion in two-dimensional and axially symmetrical flows.

Chapter 5 treats transverse mixing and longitudinal dispersion in rivers. The cumulative discharge method of Yotsukura and Cobb is nicely meshed with the classical approach. The final section of this chapter, on the dispersion of non-conservative substances, deserves more attention – it would have been helpful to point out the importance of avoiding solutions of the one-dimensional convective-dispersion equation that result in 'up-stream' dispersion.

Chapter 6 on mixing in reservoirs contains an excellent discussion of density structure and its effect on internal motions and mixing processes. The section on vertical mixing in the epilimnion takes the reader immediately to the forefront of knowledge in this field. However, it will be difficult for the average reader to appreciate the nuances of the various mixing processes without the contrasting background of the more traditional turbulent diffusion concepts introduced in the earlier chapters. Certainly the work of other investigators on wind-induced mixing in lakes and reservoirs (e.g. Stefan and Ford) deserves mention in this chapter.

Estuarine mixing, discussed in Chapter 7, includes wind-driven circulation, tidal shear, residual circulation, dead zones and gravitational circulation due to salinity gradients. The section on one-dimensional analysis of pollutant dispersion is primarily concerned with models employing the concept of averaging over a tidal period. The reader is given little insight into the advantages and disadvantages of real-time transport models. The following chapter on River and Estuary Models contains a rather abbreviated description of numerical techniques and Eulerian and Lagrangian approaches. The San Francisco Bay model is used as a case study for discussion of the role of distorted physical models.

Chapter 9 on jets and plumes returns to a more basic fluid mechanics approach in presenting the properties of non-buoyant and buoyant jets and the transition between jets and plumes. This chapter presents a good balance between integral jet models and differential equations based on the entrainment hypothesis. Individual submerged jets are treated in detail, including effects of ambient density stratification and cross flow. Important quantitative results by other investigators for buoyant surface jets and multi-port diffusers are largely ignored.

The final chapter provides a comprehensive design methodology for ocean outfalls.

The book achieves its stated purpose of presenting, in a compact manner, the considerable research achievements of the authors. In general there is a good balance between theory and application. It is recommended as a suitable text for first year graduate students and as a reference book for practicing environmental engineers.

D. R. F. HARLEMAN

An Approach to Rheology through Multivariable Thermodynamics. By HARRY H. HULL. Sponsored by the Society of Plastics Engineers, 1981. 158 pp. $16 (paperback) or $24 (hardback).

This short text is really an extended essay written presumably for those who find modern continuum mechanics and thermodynamics incomprehensible and remember from their student days that thermodynamics can produce rabbits out of hats. Much of the text is devoted to standard theory, starting with systems describable by two independent variables (P, T for example), moving on to elastomers in uniaxial tension (involving three) and discussing, rather less exhaustively, steady irreversible situations where gradients can act as additional independent variables. Unusual attention is given to nomenclature (particularly with reference to partial differentiation), to the separation of reversible and irreversible processes (particularly in terms of viscoelastic models of the Kelvin and Maxwell variety) and to the inseparability of mechanical and thermal processes. No numerical factors intrude to obscure the simple physical approach; unfortunately, it is not clear how suggestions such as that associating the first normal stress difference in simple shear directly with a change in free energy can be made use of in practice; nor is it unambiguously clear how melt flow instability can be explained in terms of Gibbs free energy (p. 115). The book does not break new ground.

J. R. A. PEARSON

Underwater Acoustics and Signal Processing. Edited by LIEF BJØRNØ. NATO Advanced Study Institute Series (Series C: Mathematical and Physical Sciences). D. Reidel, 1981. 736 pp. Dfl. 165 (US $87.00).

The current high level of research in underwater acoustics and related fields being carried out by many nations has resulted in a rapid rate of development of new experimental and theoretical techniques. In order to familiarize workers in underwater acoustics with the latest developments, a series of NATO Advanced Study Institutes (ASI) has been organized during the last twenty years. The present volume is the Proceedings of the NATO ASI held in Copenhagen during August 1980, on Underwater Acoustics and Signal Processing. Rapid advances now being made in computer technology and solid-state devices have led to cheaper digital processing, which enables more sophisticated data analysis to be carried out economically. The 1980 ASI was devoted principally to advances in signal processing and computing techniques and to their impact on the analysis of underwater acoustic signals. The ASI are intended to perform a teaching function, and so the Proceedings take the form of a collection of tutorial papers at a fairly advanced level, designed to present the latest developments in various topics to scientists who already have some background in the subject.

The Proceedings are divided into five sections. Section 1 is devoted to the sources and propagation of underwater sound. Some fairly long tutorial papers cover such topics as the effect of inhomogeneities and instabilities of the medium on sound propagation, acoustic scattering, and the modelling of stochastic propagation. Deterministic propagation modelling is also discussed at some length. Section 1 constitutes about 30 % of the proceedings and its contents emphasize the extent to which current work on underwater acoustic propagation is dominated by the stochastic effects of inhomogeneities and scattering.

Section 2 describes some recent advances in transducer technology while Sections 3 and, 4, which comprise half of the proceedings, deal with the theory and computational background of signal processing. The fact that so much of the proceedings is devoted to signal processing techniques is a result not only of the rapid advances recently being made in such fields, but also of the growing realization that underwater acoustic signals generally possess a stochastic character, and various forms of statistical processing are required in order to treat such signals. The topics covered include arrays of various types such as adaptive, beam-forming, convolution and random arrays, with discussions as to how arrays can be made to deal with random signals. There are a number of theoretical papers on the detection and estimation of random signals, digital filtering and image processing. Spectral estimation techniques are discussed as well as the transmission characteristics of underwater acoustic channels. The computational background of signal processing is dealt with in Section 4 including some of the latest advances in the application of mini-computers. Finally Section 5 presents some applications from other fields such as geophysics and radioastronomy.

As noted above this book is a collection of a large number of papers by different authors and so the quality of writing and presentation varies a good deal. Generally speaking, the papers are presented clearly and the accompanying diagrams are helpful. This applies especially to the longer tutorial papers, some of which are very good indeed. The book contains much to interest anyone working in the field of underwater acoustics. The long section on signal processing is applicable to other fields in the physical sciences and so gives the book a wider appeal.

B. J. Uscinski