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REVIEWS

Nonlinear Waves in Real Fluids. Edited by A. KLUWICK. Springer, 1991. 334 pp. DM102.

The subject of nonlinear waves in real fluids has wide-ranging implications, so the content of a CISM Lecture Course with such a title requires interpretation. The approach adopted in the lecture notes goes beyond the study of fluids in which dissipative effects due to viscosity and heat conduction are taken into account, to consider some less familiar effects, which are not always of a dissipative nature, yet nevertheless are of importance in the physical sciences due to their giving rise to new and sometimes dramatic phenomena.

Amongst some of the effects considered are waves in gases near the critical point, waves in fluids exhibiting both positive and negative nonlinearity, waves in bubbly liquids, dusty gases and fluidized beds, the dynamics of single-phase equilibria, adiabatic phase changes in liquid vapour systems (in which at least five different and distinct phase changes have been found), and waves in superfluid helium.

The accounts relate both theoretical and experimental work, and include a striking example of a natural catastrophe in the volcanic basin at Lake Nyos, in Cameroon, West Africa, in which the retrograde phase change due to Henry's Law, known as the Champagne Effect, led to a massive and sudden release of carbon dioxide causing the death by asphyxiation of many human beings and cattle.

As will be expected, asymptotic arguments play a significant part in the analysis of many of these effects, and quite apart from the contribution made by the lectures themselves to the study of nonlinear waves in real fluids, the lectures provide a good illustration of the applications of such methods to fluids. These methods are, for example, used to examine the consequence of thermoviscous effects inside shock layers and acoustic boundary layers in fluids of positive and negative nonlinearity and in the study of bubbly gases.

No account of waves in real fluids would be complete without some mention being made of equations in which a balance between nonlinearity and dissipation or dispersion leads to the occurrence of travelling waves. These lecture notes are no exception, as they contain references to, and make use of, the Korteweg–de Vries equation, the Burgers–Korteweg–de Vries equation and its modification, and the nonlinear Klein–Gordon equation. Future contributions in this area would benefit from a discussion of the significance of the effect of the sign of the so-called fundamental derivative on asymptotic methods such as the reductive perturbation method.

In summary, although the spread of topics examined is sufficiently wide that not all lectures are directly related, there is sufficient overlap to make this a useful contribution, and it is certainly one which will alert the reader to the fact that there is more to the study of real fluids than the inclusion of effects due to viscosity and heat conduction.

A. JEFFREY

Theory of Structured Multiphase Mixtures. By F. DOBRAN. Springer, 1991. 223 pp. DM42.

The development of constitutive theories for microscopically heterogeneous media is a time-honoured and still vigorous pursuit in mechanics and materials science, not to mention numerous other areas of theoretical and applied physics. One important class of such media is represented by intimate mixtures of distinct material phases which, because of their relatively large microstructural scales, can be regarded as simple continua, for example Newtonian fluids, Hookean solids, etc. Special cases notwithstanding, even this restricted class of heterogeneous media can generally be expected to show very different behaviour from that of the constituent phases. How to represent or 'model' such behaviour is a problem of compelling practical and theoretical interest, and one which attracts many researchers with different, indeed divergent, points of view and approaches.

Despite their differences, most researchers subscribe in one fashion or another to the usage of 'effective-continuum' models, be they single-phase models for some applications such as suspension rheology (e.g. in the generalized Einstein problem, involving solid particles in a viscous fluid), or multiphase models for others. As a common example of the latter, and as the name implies, the *two-phase flow* of immiscible fluids, or of fluids containing particulate solids, represents a situation where it makes good sense to keep separate accounts on phases in relative (transitional) motion.

Other situations are less clear and serve to illustrate the point that there is no clear-cut answer to some of the questions involved. For example, should one treat strongly unsteady heat conduction (or solute diffusion) in a two-phase solid composite as a single-phase continuum, with possibly complex, non-local space–time effects, such as relaxation in the time domain and/or departures from local gradient-transport in space? Or should one seek a two-phase model, with two distinct temperatures (or solute compositions) at every point of the effective continuum representing the composite? The latter approach represents the subject of the above monograph, which is concerned with the derivation of multiphase continuum models for multiphase mixtures.

The author's stated intent is to employ the microscopic volume-averaging technique (which, incidentally, is one but not the only form of smoothing or 'homogenization') to supplant the purely phenomenological, or as he calls it 'postulatory', approach embodied in the theory of mixtures advocated by certain schools of continuum mechanics. The first five chapters of the book are devoted mainly to balance equations and constitutive variables resulting from microscopic averaging, while the last three chapters are concerned with phenomenological constitutive theories.

Since the author scarcely refers to a rather large body of current research on the physics and micromechanics of heterogeneous media or to the mathematical literature on homogenization, including certain other works on volume-averaging methods, it appears that the monograph is aimed mainly at continuum mixture theorists. While leaving it to that audience to decide whether the present work succeeds in its goals (outlined on p. 5), this reader would nevertheless observe that those concerned with the distinction between grand principle and mere assumption should have some cause for disquietude. To make that point, I refer to the discussion on pp. 58–59 of 'material frame-indifference' (which, I recall, refers to the effects of material rotation rates on constitutive response).

After challenging kinetic-theory results (or, more precisely, adopting the challenge of others), the author states that 'a consensus appears to have been reached that although the kinetic theory does not provide frame-indifferent... stress and heat flux..., it does provide an excellent approximation to these... for gases which are not highly rarefied, or more precisely, for gases with the ratios of mean free molecular paths [the author obviously intends to say 'mean-free times' or 'collision times'] to the characteristic time scales of the problem much less than one... From the latest studies this much is clear: the use of the principle... can be fully justified in many practical applications and should be fully exploited in analyses. The principle... is a very powerful mathematical tool for studying the constitutive equations and will be used in this book without further questioning its validity.'

Later, on p. 75, the author states that 'the special form... of balance equations in this chapter indicates that a considerable further simplification may be achieved by ignoring the rotational effect of material relative to the centre of mass. The results obtained are worth deriving... since such a special case... produces simple, yet very powerful results.'

I submit that those concerned with physics of multiphase flow and the possible effects of rotation may fail to discern either 'power' or enlightenment in the above-quoted passages. Incidentally, neither they nor the adherents of phenomenological mixture theories will be too surprised to see that intrinsic angular momentum does not appear in the author's moment balances such as (2.4.31) and (2.4.34). At any rate, it is hard to appreciate how other mixture theories can generally be compared against such results. Thus, the critique of particular mixture theories on p. 83, based on their specialized forms of frame-indifference, left this reader quite in the dark.

With the author's main objectives presumably satisfied, we come to Chapter 6, 'Concepts and Principles of Constitutive Theory', a *tour de force* of notational complexity which raises concerns about material-symmetry principles not unlike those voiced above. If this reader has correctly interpreted the author's equations, they indicate that mixtures of isotropic materials are also isotropic (e.g. in Eq. 6.9.20). While plausible for mixtures of simple (isotropic) fluids, the result should come as quite a surprise for those who deal with fibrous solid composites or suspensions of particulate solids in fluids. I am led to conclude either that the results are restricted to mixtures devoid of phase geometry or else that the author's definition of phasic isotropy is not the standard one.

Avoiding commentary on the plethora of general linear constitutive forms offered in Chapter 7, I turn to the later discussion of constitutive models for special kinds of materials, where one will find observations (conjectures?) to the effect that surface tension should enter the equations for bubbly liquids 'through a non-local theory' (p. 167), or that capillary pressure is involved in the mechanical constitutive equations for fluid-saturated granular media (p. 176). (Is the author perhaps thinking of colloidal systems such as clay? If so, does his basic averaging technique apply to systems with van der Waals and electrostatic forces?)

There can be little doubt that, equipped with the myriad effects and disposable parameters which emerge from microscopic averaging largely devoid of microscopic physics, one can achieve a level of generality comparable to that of *ab initio* phenomenological models. Those seeking such generality may find this book helpful, while those looking or new results or insights to elucidate the mathematical foundations of multiphase models or the underlying physics would be well advised to look elsewhere.

J. D. Goddard

SHORTER NOTICES

Mechanical Design and Manufacturing of Hydraulic Machinery. Edited by MAI ZU-YAN. Avebury Technical, 1991. 536 pp. £59.50.

Vibration and Oscillation of Hydraulic Machinery. Edited by H. OHASHI. Avebury Technical, 1991. 372 pp. £49.50.

These two books are the first products of an ambitious programme of publication of books on hydraulic machinery. The programme is under the general supervision of an international editorial committee composed of 35 engineers from industrial firms and technical universities, and within each book the chapters are by different authors. The books are about the technology of hydraulic machinery rather than the science, and they will interest those who wish to compare local developments with the best international practice. Few of the writers have English as their native language, but the writing is reasonably clear if not always grammatically correct.

Heat Conduction using Green's Functions. By J. V. BECK, K. D. COLE, A. HAJI-SHEIKH and B. LITKOUHI. Hemisphere, 1992. 523 pp. £56.

This text-book is at a suitable level for senior undergraduate and first-year graduate students of engineering. It gives a comprehensive account of the use of Green's functions for the solution of partial differential equations of the heat conduction (or diffusion) type. The emphasis is on transient conduction, with steady-state solutions mostly being treated as special cases. The style is practical and helpful, with a recognition that computers play a role in real-life solutions. Two chapters are devoted to use of the Galerkin-based Green's function, and there is also a chapter on the unsteady surface-element method, which involves the matching of analytical solutions at the boundaries of bodies in contact.

Lecture Notes on Turbulence. Edited by J. R. HERRING and J. C. MCWILLIAMS. World Scientific, 1989. 371 pp. $32.

These lecture notes were prepared by students attending a summer school on turbulence at the National Center for Atmospheric Research (Boulder, Colorado) in June 1987. The four lecturers were H. Tennekes, who lectured on engineering and atmospheric turbulence, D. Montgomery on plasma and magnetohydrodynamic turbulence, D. Lilley on meteorology, and U. Frisch on turbulence theory and lattice gas hydrodynamics. The book makes a good record of some stimulating and informative lectures for those who attended, but as a text for others it has limitations.

Synoptic Eddies in the Ocean. Edited by V. M. KAMENKOVICH, M. N. KOSHLYAKOV and A. S. MONIN. Reidel, 1986. 433 pp.

This 1986 English edition is an enlarged version of the 1982 Russian edition. The 1970s showed a great surge of interest in synoptic eddies or the 'weather systems' of the ocean. The book properly reflects knowledge at that time, covering the theory of linear and nonlinear motions, statistical properties of geostrophic turbulence, eddy generation mechanisms and observations. The book has a number of similarities with *Eddies in Marine Science* (ed. A. R. Robinson), which was published at around the same time. The Russian text is rather more pedagogical in character, and with the extensive bibliography of Russian references complements the latter. There have been a number of developments since the publication of both books, particularly in the fields of numerical experimentation and observations made *in situ* and from space. Perhaps it is time for an update.

Annual Review of Fluid Mechanics, vol. 24. Edited by J. L. LUMLEY and M. VAN DYKE. Annual Reviews Inc., 1992. 546 pp. $49.

The list of articles and authors in the current volume of this periodical is as follows:

Gröbli's Solution of the Three-Vortex Problem, by Hassan Aref, Nicholas Rott and Hans Thomann.

Modeling of Two-Phase Slug Flow, by J. Fabre and A. Liné.

Measuring the Flow Properties of Yield Stress Fluids, by Q. D. Nguyen and D. V. Boger.

Contour Dynamics Methods, by D. I. Pullin.

Parabolized/Reduced Navier–Stokes Computational Techniques, by Stanley G. Rubin and John C. Tannehill.

Topological Methods in Hydrodynamics, by V. I. Arnold and B. A. Khesin.

Finite Element Methods for Navier–Stokes Equations, by Roland Glowinski and Olivier Pironneau.

Atmospheric Turbulence, by John C. Wyngaard.

Vortex Rings, by Karim Shariff and Anthony Leonard.

Helicity in Laminar and Turbulent Flow, by H. K. Moffatt and A. Tsinober.

Hydrodynamic Phenomena in Suspensions of Swimming Microorganisms, by T. J. Pedley and J. O. Kessler.

Numerical Models of Mantle Convection, by G. Schubert.

Wavelet Transforms and Their Applications to Turbulence, by Marie Farge.

Dynamo Theory, by P. H. Roberts and A. M. Soward.

Transient Flow in Pipes, Open Channels and Sewers. By J. A. FOX. Ellis Horwood, 1989. 284 pp. £55.

This book is an advanced text on one-dimensional unsteady flow. The first topic is incompressible flow in rigid and inelastic pipes. A number of graphical and analytical methods are described, including a chapter on characteristic methods. Three chapters cover the modelling of pumps, turbine valves and other devices. The description of flow in channels makes substantial use of characteristics and is followed by a short chapter on finite-difference methods. A chapter on resonance, using linearized equations, is followed by brief accounts of three-dimensional flow, compressible flow and a program listing.

Previous mastery of the basics of hydraulic flows is required. Careful reading is necessary due to a few unfortunately placed misprints and occasional lapses in the mathematics. The range of topics and methods described could be useful to civil engineers.