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BOOK REVIEWS

Handbook of Shock Waves, Volumes 1, 2, and 3. Edited by G. Ben-Dor, O. Igra & T. Elperin. Academic, 2001. 889, 792 and 421 pp. ISBN 012 086430 4.

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The complete *Handbook* consists of three separate volumes, each devoted to an exposition of a range of topics in the general field of shock wave studies. Thus, volume 1 deals with theoretical, experimental and numerical techniques, volume 2 describes shock wave interactions, and volume 3, which has Assa Lifshitz as an additional editor, is concerned with the rather more specialist material of, first, chemical reactions in shock waves and, second, an account of the structure and propagation of detonation waves. Editors are relatively few in number, but contributors to the *Handbook* are many. In all, 48 persons, editors included, have contributed to the 17 chapters into which the whole three-volume work is divided. Incidentally, chapters are numbered consecutively through all three volumes and not volume by volume. Most, but not all, of the chapters consist of several sections, which are sometimes further divided into sub-sections. Each full section is the responsibility of one or more authors and the total number of such separately authored sections is 39 in the whole *Handbook*. Ignoring the pages of preliminary material in each volume (lists of contents, etc.), there is a total of 2102 pages of scientific information available to the reader in the form of text, mathematics, graphs, diagrams, photographs and tables of results.

Chapter 1 begins with a comprehensive verbal (little or no mathematics) history of the shock wave, and concludes with a lengthy chronology of events and discoveries, covering roughly two centuries prior to 1945. This first chapter reminds the reader of the early reluctance to accept the notion that a continuum can support the existence and propagation of discontinuities, which occupied the attention of several major figures during the nineteenth century, as well as of the prolonged reluctance to accept the designation 'shock wave'.

There are several general laws that must be obeyed by shock waves travelling through matter of any kind, and these are discussed in chapter 2. For a one-dimensional steady-state system, the conservation equations can be written as a set of algebraic relations between states of equilibrium for the flow of material into the shock and the flow of material out of it. Two particularly useful relations can be extracted from these algebraic equations. The first, called the Hugoniot relation, provides a link between purely thermodynamic quantities and the second, known as the Rayleigh-line relationship, connects local pressures and specific volumes with the speed of propagation of the shock. Both Hugoniot-curve and Rayleigh-line relationships apply to any material but it is clear from the fact that, in its basic form, the Hugoniot equation involves pressure, specific volume and internal, or intrinsic, energy, that one must also have information about the equations of state (EOS for short) for a particular material before one can solve the shock-wave problem.

The precise form of the EOS has a crucial influence on the behaviour of the shock, and it is therefore necessary to engage with the details of thermodynamic formulae. Three parameters are of special significance; they are (i) the adiabatic exponent $\gamma \equiv (v/p)(\partial p/\partial v)_s$ (ii) the Grüneison coefficient $\Gamma \equiv (v/T)(\partial p/\partial s)_v$ and (iii) the fundamental derivative $G \equiv (v^2/2p\gamma)(\partial^2 p/\partial v^2)_s$ where p, v, T and s are absolute pressure, specific volume, absolute temperature and specific entropy, respectively; $(\,)_q$ indicates that the differentiation inside the parentheses is to be taken with quantity q fixed. Various constraints on the system of laws that govern behaviour of shocks can be expressed in terms of these dimensionless parameters, and these matters are thoroughly explained in chapter 1. For example, if, as is true for most materials, G is positive it follows that passage of material through a shock must take place from low pressure to high pressure in order for the second law of thermodynamics to be obeyed.

However, some materials within a domain of states close to their vapour/liquid boundaries have negative values of G, which means that it is then a wave of expansion that can travel as a discontinuity. Section 3.4 in volume 1 is devoted to an extensive exposition of dynamical behaviour in these ‘unusual’ materials, which have potential for use in practical applications, as explained at the end of that section. Negative values of G also occur in metals at their yield point.

Chapter 3, which consists of several individual sections, has as its general title the “Theory of Shock Waves”. Section 3.1 deals with shocks in gases, and two short sections, 3.2 and 3.3, provide some information about the nature of shocks in liquids and in solids, respectively; the contents of section 3.4 have been outlined in the previous paragraph. Section 3.5 has interesting things to say about the stability of shocks treated as discontinuities, and concludes with some remarks on the stability of shock jumps that are followed by relaxation zones, as in the widely used model of a detonation as a shock jump followed by a relaxation layer across which combustion reactions, switched on by the discontinuous shock, progress to a new state of equilibrium. Section 3.6 describes shock waves in space, by which is meant waves that travel through a plasma embedded in a magnetic field. Such waves must be modelled by the equations of magnetohydrodynamics. Section 3.7 provides a comprehensive account of shocks travelling through tubes of varying cross-sectional area into both quiescent and moving gases. Concentrating on the behaviour of the discontinuity surface, and making the assumption that the flow behind this surface does not exert a strong influence upon it, this section explains and exploits the very successful method of geometrical shock dynamics.

Chapter 4 describes the several different laboratory facilities within which shocks can be generated, observed and measured, and chapter 5 is devoted to an exposition of methods of flow visualization and the use of spectroscopic diagnostics which enable one to follow distributions and concentrations of individual species, both stable and transient in, for example, shock tube flows.

The final chapter in volume 1 is an account of numerical methods that are capable of producing accurate solutions of partial differential equations and equations of state when shock waves, treated as discontinuities, are essential features of the fields that are to be modelled.

Volume 2, with the title “Shock Wave Interactions & Propagation”, consists of nine chapters, the first three of which deal with interacting waves. Chapter 7 discusses one-dimensional interactions and chapters 8 and 9 describe two-dimensional situations and axisymmetric reflections, respectively; the dimensions referred to here are spatial. Interacting waves in two spatial dimensions produce a rich variety of configurations (regular reflections and the various types of Mach reflections) that have been a subject for extensive and careful observation and calculation for many years. Understanding of interactive events is now in a very satisfactory state … one is almost tempted to say complete, but that would be unwise … and it is certainly true to say that the accounts of interactions given in the *Handbook* are exceedingly thorough.

Shocks in ‘channels’, exemplified by mine shafts and long pipelines, both of which may well consist of several branches, are described in chapter 10. Practical reasons for the study of systems of this sort go without saying.

When a shock or blast wave converges on a point, very high pressures and temperatures can be created in the neighbourhood of the focus. Chapter 11 deals with both theory and observation of such processes and chapter 12 discusses applications of such focused shock waves in medicine, especially their now almost routine use in extracorporeal shock wave lithotripsy for the treatment of various stones that can afflict the human body.

The term blast wave is generally used to label the combination of an expanding shock wave and its associated flow field, both having been created by a sudden release of energy in a concentrated region within the field. There is particular interest, for obvious reasons, in the configuration that has spherical symmetry. Despite its superficially simple configuration, the spherical blast wave is not susceptible to exact analytical treatment. If energy is released within a central spherical domain the resultant configuration does not obey any simplifying self-similarities, save as an approximation for very strong shocks. Chapter 13 describes various ways to approach a theoretical solution of the problem, as well as the results of observations of energy release in close proximity to a 'ground' plane.

A feature of the spherically expanding shocks described in chapter 13 is the creation of a contact surface that separates ambient gas processed by the primary shock from the material within which the energy has been released. This contact surface or interface exists in a flow field that is accelerating, which means that it may be susceptible to instabilities. Chapter 14 presents a thorough examination of the role of shock waves in establishing interfacial instabilities of the Rayleigh–Taylor and Richtmeyer–Meshkov types.

Chapter 15, with the title "Shock Wave Propagation in Multi-Phase Media", consists of four sections. Section 15.1 deals with questions that arise when a shock wave, propagating through a homogeneous gas (most frequently, atmospheric air), impinges on a porous medium. It is surprising how many questions are posed by such a superficially simple situation and how difficult it is to arrive at completely satisfactory answers. Even observations, frequently made in a shock tube, are beset by numerous difficulties. The account of these matters presented in section 15.1 is clear, comprehensive and should certainly be read by anyone thinking of embarking on their own investigations into this topic. It is important to be aware of the structural character of the porous material itself (e.g. does the solid skeleton that defines and supports the porosities flex under assault from the shock, or is it an effectively rigid structure?) since it is now clear that this internal structure is influential in determining responses to the incident shocks.

Granular materials are important in a wide variety of scientific and engineering fields. The introduction to section 15.2 makes explicit mention of several of these, but the authors choose to write about advances, made in recent times with one rather particular example, namely the interaction between a weak shock and granular material that is inert, and to concentrate their attention on experiments.

Section 15.3 describes investigations, theoretical and experimental, aimed at understanding interactions between an incident shock and the bubbly liquid through which it is propagating, especially when there is a lack of pressure equilibrium between the liquid and the gas phases; interactions can also arise from the absorption and reradiation of shock wave energy by the two-phase medium. When the bubbles are filled with reactive gas the system can support detonations, a matter discussed in the later parts of the section.

Finally, section 15.4 analyses the case of a shock propagating in a mixture of gas, vapour and droplets. The latter, being comparatively heavy, are not immediately affected by their passage through the shock and the problem is distinguished by the need to understand the structure of the relatively slow rate of relaxation behind the shock to a new state of equilibrium. The situation is encountered in the propagation of weak shocks through fogs and with standing shocks in the flow of wet steam through the Laval nozzles of steam turbines.

Volume 3 of the *Handbook* has the slightly ambiguous title "Chemical Reactions in Shock Waves and Detonations". It deals first, in chapter 16, which has the overall title "Chemical & Combustion Kinetics", with the exploitation of shock waves and shock tubes to produce chemical and internal-molecular states of disequilibrium. The general character of such states in gases has been described previously in section 3.1.5 and section 3.5.3.6 deals with the stability of what are called 'two-front models'. The first 'front' is the leading part of the shock layer within which translational and rotational modes of molecular motion approach states of local equilibrium in a very few molecular collision intervals. The first 'front' is followed by a second 'front' or layer, often called more helpfully a 'relaxation zone', within which molecular vibrations and chemical conditions equilibrate, frequently over durations of very many molecular collision intervals. The description of spectroscopic diagnostics in section 5.2.1 is very relevant to matters of this kind. The evolution of these states of disequilibrium can be analysed to provide a wealth of information about the kinetics of the various reaction and relaxation processes that take place in these circumstances.

The second chapter in volume 3, numbered 17, is a single-author work with the title "Combustion, Detonation and Deflagration". It provides a first-class description of the essential, interacting, processes that are responsible for the propagation of fully established detonation waves. Of course, combustion reactions provide the energy to drive such waves, but the vital role played by compressible turbulence in the structure of steadily propagating detonations is clearly brought out, I believe for the first time with this clarity.

Within the compass of a review it is not possible to give more than a brief glimpse of some of the enormous amount of information contained in the three volumes that make up the complete work. With so many authors involved in its construction, there are bound to be variations of style, depth and clarity of presentation. On my way through the text I noticed a few typographical errors and, if there were changes in notation from one section to another, potentially a problem in situations like the present one, they did not stand out and did not make it difficult to understand the text.

Anyone in need of an authoritative summary of shock wave studies at the beginning of the new millennium should certainly consult the *Handbook*, which brings me to a not-very-serious comment. The *Concise Oxford Dictionary* (9th edition, 1995) defines the word handbook to mean *a short manual* …

J. F. Clarke

SHORT NOTICES

Dynamics of Internal Gravity Waves in the Ocean. By Yu. Z. Miropol'sky. Translated and edited by O. D. Shishkina. Kluwer, 2001. 406 pp. ISBN 0-7923-6935-1. EUR 138.00 or US$149.00 or £95.00.

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Breaking internal gravity waves are thought to be the main cause of mixing in the ocean and hence exert a key influence on climate and marine productivity.

This monograph concentrates on the theory of linear and nonlinear internal waves and their interactions with shear flows and with each other. It is basically a clear translation of a 1981 monograph in Russian by the late Yuri Miropol'sky, though some rather limited updating of the material and the references has been carried out. The book will chiefly be of value to scientists in the west who are now returning to the difficult theoretical questions of internal waves and their nonlinear interactions and will be interested in a digest of the older Russian literature.

General Circulation Model Development. Edited by D. A. RANDALL. Academic, 2000. 803 pp. ISBN 0-12-578010-9. £62.95.

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This book presents the proceedings of a symposium held in July 1998 at UCLA in honour of Professor A. Arakawa. There are 23 multiauthored chapters, the first and last being by Professor Arakawa himself. Many of the chapters seek to provide an overview of a topic rather than a research contribution; others give a history of model development. An overall index is provided.

Calculation of Complex Turbulent Flows. Edited by G. TZABIRAS. WIT Press, 2000. 400 pp. ISBN 1-85312-645-4. £137.00 or US$212.00.

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This volume contains nine multiauthored papers concerned with the computation of complex turbulent flows in engineering geometries. Both compressible and incompressible flows are considered, and the relative performances of a number of closure models are examined.

The Motion of Bubbles and Drops in Reduced Gravity. By R. SHANKAR SUBRAMANIAN & R. BALASUBRAMANIAN. Cambridge University Press, 2001. 471 pp. ISBN 0 521 49605 5. £65.00.

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This book is concerned primarily with the motion of drops (or bubbles) driven by gradients in surface tension arising from an imposed temperature gradient. Theoretical studies treating spherical drops are given a thorough and comprehensive review. The book deals with both individual drops and those interacting with other drops or nearby boundaries, and a range of analytical and asymptotic techniques for tackling these problems are presented. The effects of body forces, surfactants, surface reaction and mass transfer are included. Much of the book is based on the authors' own contributions to the field. Theoretical results are supported by comparisons with experiments conducted in a low-gravity environment. Relevant computational studies are also described, although numerical studies of flow-induced drop deformation are given less attention. Introductory chapters provide overviews of fundamental concepts, theories and analytical techniques, and a final chapter provides an account of thermocappillary flow in slots and liquid bridges. This book will be a valuable reference text for those interested in interfacial and low-gravity fluid mechanics.