# Book Reviews

## *Handbook of Shock Waves Volume 1: Theoretical, Experimental, and Numerical Techniques*

Edited by G. Ben-Dor, O. Igra, and T. Elperin, Academic Press, San Diego, CA, 2001, 889 pp., $1500.00 (3-volume set)

This extensive volume brings together 17 chapters from shock wave experts around the world. The work is arranged in six main chapters. The first is an extensive history of shock waves (and supersonics) starting from speculation about thunder in early times up to 1945, after which most of the work reported in subsequent chapters takes place. It makes entertaining reading and includes a 100-page, 200-year descriptive chronology, followed by 500 references. The next chapter is a concise and formal treatment of the general laws for propagation of shock waves through matter, which emphasizes the importance of the equations of state to the results obtained.

The third main chapter, on the theory of shock waves, has seven subchapters and constitutes over 40% of the book. Chapter 3.1 on gases is well thought out and extensive and includes real gas effects (i.e., vibrational relaxation), detonation tubes, and oblique detonation waves. Chapter 3.2 applies the Mie–Gruneisen equation of state to liquids, discusses the Tait equation form, and includes application to explosively generated shocks in water. Chapter 3.3, dealing with shocks in solids, builds on Bethe's comprehensive work and includes experimental methods. This is followed by a scholarly (and somewhat abstract) chapter on the possibility of rarefaction shocks and a similar one on shock stability. A nice chapter on shock waves in space is next, in which collisionless shocks are discussed. Finally, Chapter 3.7, on geometrical shock dynamics, discusses the approximation due to Chester, Chisnell, and Whitham that allows many complex shock interactions to be readily analyzed (i.e., shock diffraction).

The fourth chapter, entitled "Shock Tubes and Tunnels: Facilities, Instrumentation and Techniques," deals with methods for producing flows involving shock waves. Chapter 4.1 is a straightforward review of ideal-gas shock tubes, and Chapter 4.2 briefly discusses high-performance drivers, leading to the free-piston technique and a few results from these facilities. The next brief chapter discusses renewed interest in expansion tubes, which offer higher total temperatures and pressures at the expense of test time. Blast tubes are reviewed in Chapter 4.4, including explosive design and applications. The construction and operation of supersonic wind tunnels is reviewed in Chapter 4.5.

Chapter 5, dealing with measurement techniques and diagnostics, has two subchapters, both concerned with nonintrusive photon techniques. The chapter on flow visualization provides an extensive discussion of optical flowfield methods. These are illustrated with photographic results of a test flow taken with eight different systems, including color schlieren and shearing and holographic interferometry. Chapter 4.2 deals with spectral methods and describes UV, visible, and infrared absorption techniques, atomic resonance absorption, and planar laser-induced fluorescence. Tables are presented for designing experiments for detection of specific molecules.

Finally, Chapter 6, on shock capturing, deals with increasingly powerful numerical methods of solving the Euler equations. Many techniques for reducing numerical dissipation and increasing efficiency and robustness are discussed. It is comforting to learn that there is no clear favorite and that the literature can appear "bewildering" to a beginner.

This overview is meant to highlight some of the content of this extensive reference. In general, the selection and ordering of material is logical and the formatting and editing excellent. The level of the material is generally high; in fact, some of the material will be a little difficult for the nonspecialist. But this is a reference book not a textbook, and the extensive references at the end of each chapter should help. Users may have their own ideas about topics that should have been included or could have been excluded. In the reviewer's view, inclusion of a broad review of boundary-layer effects on shock motion and on flow uniformity and test time in shock facilities would have been valuable (perhaps at the expense of the chapter on supersonic flow facilities). There is a chapter on shock-wave/boundary-layer interactions in Volume 2, which ideally includes some of this material. Also, a discussion of calculations and measurements of the structure inside the simplest shock wave (monatomic) would add completeness.

All in all, this volume, like the biennial proceedings of the International Symposia on Shock Waves, reinforces the amazing breadth and depth to be found in the study and application of shock waves. I will enjoy having it on my reference shelf, congratulate the editors for a job well done, and look forward to perusing Volumes 2 and 3!

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## *Handbook of Shock Waves Volume 2: Shock Wave Interactions and Propagation*

Edited by G. Ben-Dor, O. Igra, and T. Elperin, Academic Press, San Diego, CA, 2001, 780 pp., $1500.00 (3-volume set)

This volume of the handbook, written by experts in the field, is a treasure trove of the state of the art in the diverse manifestations of shock waves. One is impressed by the sheer variety of phenomena covered in the nearly 800 pages. As can be expected in a work of this nature, the treatment is not consistent, with certain topics addressed in depth and others relegated to a short review. A combination of analysis, numerical modeling, and physical experiments appears in the chapters. However, the discussion of these methods is not often balanced. This may reflect the authors' bias, the relative state of the art of these methods as applied to a particular problem, or the nature of the problem itself.

This second volume of the set starts off with Chapter 7, "One-Dimensional Interactions," which concentrates on the classical, precomputer approach. Despite such a remark, one-dimensional approaches are still used due to their simplicity. Moreover, many real flows are approximated as quasi-one-dimensional with reasonable accuracy. This is evident in the later chapters, many of which make use of one-dimensional ideas to shed light on the phenomenon under consideration. Some of the phenomena considered include interactions between a shock wave with another shock, with a rarefaction wave, and with a contact discontinuity. Toward the end of the chapter, the author discusses the head-on collision of a planar shock with a nonrigid wall. To bring the material up to date, the author includes a discussion of a general Riemann problem solver.

Chapter 8, "Two-Dimensional Interactions," is a lengthy chapter comprising three sections, namely, "Oblique Shock Wave Reflections," "The Refraction of Shock Waves," and "Shock Wave/Boundary Layer Interactions." These topics are the subject of disparate treatments. The section on oblique shock reflections thoroughly reviews the topic and appears to be an updated summary of the author's previous monograph.[1] Emphasis is placed more on understanding the phenomena and less on methodology. Important topics such as criteria for regular to irregular transition, the existence of a dual-solution domain, and hysteresis in the transition are included. Shock reflections in steady, pseudo-steady, and unsteady flows are described as well, including the effects of various surface conditions, viscosity, and real gas. This section brings the reader up to date on topics of contemporary interest.

The section on shock-wave/boundary-layer interactions (SWBLI) provides an adequate update of two-dimensional interactions, including control concepts. The author also makes use of shock polars to elucidate the interaction process. Upstream influence, incipient separation, and free interaction concepts are adequately discussed. Physical insight into two-dimensional SWBLI is provided through triple-deck theory via a qualitative discussion. However, rapid distortion theory, which is useful, is not mentioned. Reference is not made to extensive AGARDograph compilations that provide benchmark data for workers in this field.[2] The widespread research into turbulent interactions, including unsteadiness, is likewise inadequately summarized. Despite their importance, three-dimensional interactions are sketchily described.[3] In summary, this section is of somewhat limited utility for introducing newcomers to the field.

Finally, the section on the refraction of shock waves is a brief summary of work primarily by the author and his co-workers. The discussion is analytical, with strong reliance on shock polars. The reviewer is surprised by the lack of inclusion of experimental data or computational results of complex refraction situations, e.g., through a nonhomogeneous medium, where analytical approaches may be difficult to apply.

Chapter 9, "Axisymmetric Shock Wave Reflections," is an appropriate extension of the materials covered in the preceding chapters. This topic is of practical utility, being encountered in internal and external flows, such as nozzles and intakes. Much less material is available on conical reflections, and the chapter skillfully highlights the similarities and differences between conical and wedge reflections. The first encounter with the Chester–Chisnell–Whitham (CCW) theory in this volume is found in this chapter. CCW theory, also known as ray shock theory, provides details of the main shock front, neglecting the reflected wave. Examples of conical Mach reflections using this theory, including comparisons with experiment, are given. The utility of numerical simulations to complement physical experiments for evaluating and supporting theory is pointed out. This chapter, overall, is well written and provides a balanced view between theory, physical experiment, and numerical simulation.

Chapter 10, "Shock Waves in Channels," is of importance from a practical viewpoint. A description is given of wave phenomena found in small- to full-scale testing, supported by visualizations of numerous configurations as may be encountered in reality. Large-scale experiments generated numerous databases. The authors give an evaluation of the relative merits and demerits of these different approaches. The CCW theory again finds application here and proves to agree well with experimental observations. The authors also describe numerical methods, including the SHAMRC (Second-order Hydrodynamic Automatic Mesh Refinement Code) and the GRP code.

Chapter 11, "Shock Wave Focusing," is a brief chapter covering a topic that is touched on briefly in Chapter 10, as well as in Chapter 12. The author describes some experimental apparatus for producing imploding cylindrical and spherical shock and detonation waves. Theoretical approaches such as the CCW theory and similarity methods are described, and numerical simulations are mentioned. Despite the brevity of this chapter, sufficient material is included to bring the reader up to speed on the physics of the problems and methods for addressing them.

Chapter 12, "Applications of Shock Waves in Medicine," is, curiously, the only chapter that deals explicitly with applications. The reviewer can think of other prominent applications, including oblique and pulse detonation wave engines, wave rotors, and ram accelerators, that warrant separate discussion. In the medical field, the development of needle-less drug delivery through shock waves has great potential. Also, lithotripsy of gallstones is worth some discussion. The primary focus of this chapter is on extracorporeal shock wave lithotripsy (ESWL) of urinary calculi. In this regard, it is a well-written summary of the techniques available for performing ESWL.

Chapter 13, "Spherical Shock Waves," consists of a section on expanding spherical shocks, or blast waves, followed by a short section on the attenuation of spherical shock waves propagating in a gas. The chapter reviews the physical properties of an expanding blast, followed by analytical, computational, and experimental techniques. Scaling laws related to the energy released at the center and the properties of the ambient gas are described.

Chapter 14, "Shock Induced Instability of Interfaces," is essentially concerned with Richtmyer–Meshkov instability. An ample background on the Rayleigh–Taylor instability is first provided. The chapter offers a comprehensive review of analytical approaches (perturbation method), experimental studies, and computations. Experimental and numerical difficulties are highlighted. The authors describe early and late time scaling laws. They also list a number of outstanding issues.

Chapter 15, "Shock Wave Propagation in Multi-Phase Media," is a long, multiauthor paper divided into four sections. The first two sections on "Shock Wave Propagation in Porous Media" and "Weak Shock Wave Interaction with Inert Granular Media" are arranged in a similar manner. They describe the phenomena and various ways of modeling the respective media. Analytical, experimental, and numerical approaches are all adequately covered. The last two sections are entitled "Shock Waves in Inert and Reactive Bubbly Liquids" and "Shock Wave Interaction with Liquid Gas Suspensions." The mathematical modeling for these interactions is quite involved and is well described by the authors, as is the complex nature of the interactions.

To continue with the analogy of a treasure trove, this volume contains precious jewels, some more brilliant than others. Some possess flaws, but all are, nonetheless, valuable in providing a comprehensive summary of the state of the art. Throughout the volume, the reviewer thought that the authors consciously or unconsciously were imparting the impression that the topics are mature. This is perhaps the nature of the reviews. Some authors did pose outstanding issues of current interest that added value to the reviews. There are some glaring omissions in this collection. Some technologically important topics, such as shock–shock interactions, shock/vortex interactions (including blade/vortex interactions), high-speed mixing, and shock and blast wave interactions in single-phase liquids, are missing. These should perhaps be appropriately placed in this volume. Some esoteric subjects such as volcanic eruptions and exploding stars may appropriately find a place in this volume as well. The possible inclusion of these topics would not enlarge the volume inordinately if the length of some of the existing papers were reduced. Despite the large number of topics, the volume has a good table of contents and index to help the reader navigate through the material. The reviewer views this handbook to be a convenient reference but, alas, not on the shelf of many an investigator due to the unfortunately high price of this treasure.

## References

[1]Ben-Dor, G., *Shock Wave Reflection Phenomena*, Springer-Verlag, New York, 1991.

[2]Fernholz, H. H., Finley, P. J., Dussauge, J. P., and Smits, A. J., "A Survey of Measurements and Measuring Techniques in Rapidly Distorted Compressible Turbulent Boundary Layers," AGARDograph 315, 1989.

[3]Settles, G. S., and Dolling, D. S., "Swept Shock-Wave/Boundary-Layer Interactions," *Tactical Missile Aerodynamics: General Topics*, edited by M. J. Hemsch, Vol. 141, Progress in Astronautics and Aeronautics, AIAA, Washington, DC, 1992, pp. 505–574.

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## *Handbook of Shock Waves Volume 3: Chemical Reactions in Shock Waves and Detonations*

Edited by G. Ben-Dor, O. Igra, T. Elperin, and A. Lifschitz, Academic Press, San Diego, CA, 2001, 421 pp., $1500.00 (3-volume set)

This is the third and the last volume of the title book. In this volume, application of shock tubes to chemical kinetics and combustion studies is described in seven chapters by R. D. Kern, H. J. Singh, Q. Zhang, J. H. Kiefer, J. V. Michael, A. Lifshitz, W. Tsang, H. Wang, and H. S. Lee. Topics covered include mass spectrometry, resonance absorption spectrometry, single-pulse shock tube technique, ignition delays, particulate formation, and detonation. Pages of references are given at the end of each chapter.

This volume is an excellent summary of the techniques and results of the topics covered. For instance, the book lists 111 reactions and their rate constants associated with ignition delay. Even though several books of a similar nature were published in the past, this book is up to date and contains sufficiently new material for one to pay attention. For instance, the use of the expanding region of the single-pulse shock tube for the study of recombination processes as discussed in some depth in this book has hitherto not been brought to the attention of the community beyond those directly involved. There are many periodicals and symposium series devoted to chemical kinetics and combustion. For an outsider, it is impossible to spend only a few days and grasp the situation, and so this volume is ideal for such a reader.

The aerospace community has traditionally been deeply involved in chemical kinetics, combustion, and particulate formation phenomena. Indeed, much of the contents covered in this book pertains to aerospace applications. Most of those problems associated with conventional propulsion systems could be considered to have been solved. However, for futuristic propulsion systems such as hybrid engines and ramjet and scramjet engines, problems remain. For instance, the recombination processes in the hydrogen–oxygen system, which is critical in scramjet nozzle flows, have not yet been satisfactorily studied experimentally. This book will be a good guide for those interested in these new problems. For instance, the single-pulse shock tube mentioned may be an ideal tool for studying recombination processes in scramjet nozzles.

One area not covered well in this book concerns chemical kinetics problems associated with planetary entry flights, which are exclusively of aerospace origin. Nonequilibrium phenomena in air are mentioned to some extent in this book, but little attention is paid to the phenomena, or the experimental techniques to study them, in the carbon dioxide–nitrogen mixtures of Mars and Venus, hydrogen–helium mixtures of Jupiter and Saturn, or methane–nitrogen mixture of Titan.

The aerospace technology community is undergoing change. Those who are searching for new directions outside aerospace applications may obtain some ideas from this book. For instance, could the single-pulse shock tube technique be used in studying the process of formation of carbon nanotubes?

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