AIAA JOURNAL
Vol. 40, No. 11, November 2002

Book Review

BOOK REVIEWS published in this section reflect the opinions of their individual authors. They are not necessarily the opinions of the Editors of this journal or of AIAA.

Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena

Yakov B. Zel'dovich and Yuri P. Raizer, Edited by Wallace D. Hayes and Ronald F. Probstein, Dover Publications, Inc., New York, 2002, 916 pp., $34.95

I have known about this book since my graduate school days, but it has become difficult to get one of the very limited number of copies, originally issued in two volumes. Over the years, my research has taken me to different areas, and I often wondered what I had missed until I received the recent Dover edition. It would be very difficult to find another book that addresses such a wide variety of subjects on high-temperature physics in gasdynamics, ranging from explaining the basic physics to, in some cases, providing working knowledge for applications. As in all classic literature, the references are dated but timeless. The renowned authors' approach to all topics is based on a fundamental understanding and unique insight, and so it has easily withstood the test of time. The fundamental treatises of shock wave structure, chemical kinetics, and internal degrees of excitation of high-temperature gases, as well as radiative heat exchange, reflect the extraordinary breadth and depth provided by the authors. In addition, the equally renowned editors offer incisive notes on the rigorous scientific disciplines covered in the text.

The first three chapters of the book are focused on the fundamental gasdynamics of shocks, radiant heat exchange, and thermodynamic properties of gases at high temperature. This section of the book provides an insightful description of basics and yet requires a certain degree of discipline from the readers to follow the authors' line of thought. The chapter on shock tubes is a good introduction to experimental devices and is easy to read. The subsequent two chapters discuss the key nonequilibrium phenomena in high-temperature gases during radiation and relaxation processes. Then the subjects of detailed shock wave structure and chemical kinetics are followed by the study of radiative phenomena associated with explosions in air. These topics bridge overlapping areas of different technical disciplines. Nevertheless, the chapter on thermal waves is very interesting and can be easily appreciated. After the discussion of shock waves in solids, which is truly a specialized subject in science, self-similar processes in gasdynamics are brought forward. The final chapter reveals extraordinary observations and collective wisdom covering motion of a gas under an impulsive source. This final chapter also stands alone in its presentation style and the use of mathematical description to delineate a family of complex physics.

This remarkable book, describing nearly all aspects, and the most complex, of high-temperature gasdynamic processes, is interdisciplinary, and yet the coverage of all subjects is reasonably balanced. It is particularly impressive in the comprehensive introduction of absorption and emission of radiation in high-temperature gases from atomic line spectra to molecular band spectra. It flows smoothly and makes the complicated quantum physics topics readily understandable. Although significant advances have been made in nonequilibrium radiation heat transfer, these sections still stand out as the best basic knowledge source in this discipline. Similar observations can also be made regarding the discussions of relaxation phenomena in rotation, vibration, dissociation, and ionization internal degrees of freedom of high-temperature gases. The presentation is thorough and systematic. In addition, quite a few well-known high-temperature gas behaviors are illustrated by specific data that can only be derived from an unbelievably broad working experience. This knowledge can otherwise only be extracted from an array of books or a large collection of the literature.

In general, the mathematical derivation of a discussed topic is a supplement to the brilliant and in-depth physical explanation in the text. The section on self-similar solutions in gasdynamics is a singular exception. This section truly reveals the enormous underlying foundation for blast-wave theory and the law of plane-cross-sections that was developed in what is now Russia. One begins to understand that all of these outstanding findings indeed originated from strokes of individual ingenuity. However, these remarkable achievements were also nurtured by collective wisdom.

In summary, this book is a one-of-a-kind knowledge resource that covers interdisciplinary subjects of great interest in high-temperature gasdynamics. The publication of the new Dover edition is especially timely considering the recent rejuvenation of magnetohydrodynamic research for hypersonic aerodynamic performance enhancement. It is also an invaluable reference for fascinating new possible directed energy applications, such as powerful microwave propagation and breakdown processes in laser heating, and thus is an essential reference for high-speed flight. For these reasons alone, this book is highly recommended for scientists and engineers in hypersonic flow research.

Joseph J. S. Shang
Wright State University