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BOOK REVIEW

John H. S. Lee: The Detonation Phenomenon

Cambridge University Press, 2008. ISBN-13: 978-0521897235

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The phenomenon of detonation, characterized by features which evolve non-linearly over a wide range of length and time scales, is one which provides a rich opportunity for scientific study. Its multiscale nature brings with it challenges for both experimental and computational rendering. Its non-linear nature admits some phenomena which are straightforward to explain and others which belie easy understanding. These challenges are appreciated and discussed vigorously in John H. S. Lee's *The Detonation Phenomena*, a new monograph focusing in the author's words on giving "a description of the detonation phenomenon, explaining the physical and chemical processes responsible for the self-sustained propagation of the detonation wave, the hydrodynamic theory that permits the detonation state to be determined, the influence of boundary conditions on the propagation of the detonation, and how detonations are initiated in the explosive." These are worthwhile goals, and the author succeeds admirably in reaching them.

This is a book with a focus: the science of gas phase detonations with an emphasis on mechanistic explanation of observations. Detonation in condensed phase materials is not considered in detail, nor is engineering of devices relying on detonations. The book is accessible to a reader who has understanding at an advanced undergraduate level of gas dynamics and an interest in reactive fluid mechanics. It would be useful as a graduate text in a class devoted to gas phase detonation, and also for any professional, including many readers of *Shock Waves*, with an interest in detonation science. The author's qualifications are impeccable; he has published regularly in the detonation literature since the late 1960s and is a recognized leader of the international detonation science community.

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A key strength of this book is its comprehensive, and in places, stunning display of the experimental record of complex detonation dynamics. This is accompanied by lucid and plausible phenomenological explanations of observations, often supported by straightforward, mathematically based theories. It is closest in spirit to Fickett and Davis's *Detonation*, which will probably remain the first choice of readers who want an exposition of detonation theory nicely supported by experimental observation. However, Lee's monograph is likely to be the first choice of those seeking the converse: a *tour de force* of experimental detonation science well supported by mathematical theory. The bookshelf of anyone seriously studying detonation will not be complete without either book.

The book is divided into nine chapters. The first gives a basic introduction to detonation and some of the early literature, with novel discussion of some of the finer historical points. Chapter 2 appropriately gives a standard treatment of one-dimensional steady Chapman–Jouguet theory. One can quibble with nuances of notation (e.g. the role of Y and X for mass and mole fraction being reversed from that more commonly found) or the simplified model assumptions (e.g. the roles of diffusion, temperature-dependent properties, and detailed chemical kinetics are not emphasized), but the overall treatment is sound. Chapter 3 continues to build fundamental mathematical theory, here discussing the motion of the reacted gases. The theory is expanded to treat one-dimensional unsteady flows with geometric divergence. The method of characteristics is employed to draw basic conclusions regarding the dynamics of the product gases. Chapter 4 addresses steady planar one-dimensional detonations with competition between advection and finite-rate chemical kinetics; in short, the standard theory of Zel'dovich, von Neumann, and Döring is presented.

Chapter 5 summarizes a variety of theoretical work on unstable detonations, nicely exposing foundational work from the 1960s as well as some of the most recent studies which describe the transition to chaotic dynamics. Most attention is rightly given to the classic inviscid one-dimensional model with one step kinetics; however, effects of detailed kinetics and multi-dimensionality are discussed as well. Chapter 6 begins the formal treatment of experimental observations. The author gives a thorough presentation of intrinsic multi-dimensional instabilities including spinning detonations and cellular structures. These two chapters form a key contribution which distinguishes the monograph from nearly all existing comparable works: a well juxtaposed discussion of modern unsteady simulations and experiments, with appropriate historical perspective. This will serve as a useful source for future scholars who will want to extend the discipline to determine how the competition between advection, reaction, and diffusion defines the striking variety of self-organized dissipative structures observed in detonation.

Chapter 7 turns to how boundary conditions can alter these intrinsic dynamics. Here the role of curvature is discussed. While the literature review is generally good, the author missed here an opportunity to highlight the seminal 1981 study of Bdzil on detonations with curvature. Next, Chapter 8 considers the problem of deflagration-to-detonation transition (DDT) in tubes of finite dimension, a problem where both intrinsic and boundary effects are relevant. The author distinguishes DDT, which he characterizes as relatively slow, from the topic of Chapter 9, a so-called "direct" initiation, which is relatively fast. Here the impetus for the detonation is not flame acceleration, but an initial condition in which a large concentration of energy is suddenly released, inducing a more rapid transition to detonation. In practice, distinction of these two classes of events is clear, though one might imagine that as the strength of the "direct" initiator is continuously reduced that there would be a consequent continuous evolution to the slower DDT.

In summary, Lee has given the community an excellent new monograph summarizing well the state-of-the-art of gas phase detonation science. The strengths of the book are many, but perhaps its greatest is its refreshing candor in advocating scientific understanding for its own sake. It reflects well the author's long and useful provocation of the detonation community to try to better explain an interesting slice of nature.