

BOOK REVIEWS

EDITED BY NICHOLAS D. KAZARINOFF

Mathematical Problems from Combustion Theory. By Jerrold Bebernes and David Eberly. Springer-Verlag, New York, 1989. x + 178 pp. \$34.00. ISBN 0-387-97104-1. Applied Mathematical Sciences, Vol. 83.

Mathematical problems involving nonlinear forcing, or source terms, are well exemplified physically by combustion processes, which are usefully modeled as involving strongly temperature-sensitive rates of chemical reaction. Depending on the type of interaction that becomes important under appropriate prevailing conditions, a wide range of interesting problems can be extracted for detailed analysis. In this deceptively thin volume, Bebernes and Eberly start with a sketch of the Navier-Stokes equations augmented by chemical behaviour and show how two basic families of problems (which they describe as *solid fuel models* and *gaseous fuel models*) can be extracted. The behaviour of the resulting systems proves to be very rich and so offers a challenging field for mathematical analysis.

The "solid fuel" models apply in a domain $\bar{x} \in \Omega$ and satisfy the equations

$$(1) \quad \begin{aligned} T_t - \Delta T &= \epsilon \delta y^m \exp\left(\frac{T-1}{\epsilon T}\right), \\ y_t - \beta \Delta y &= -\epsilon \delta \Gamma y^m \exp\left(\frac{T-1}{\epsilon T}\right) \end{aligned}$$

along with suitable boundary and initial conditions. In the limit as $\epsilon \rightarrow 0$, the reduced model

$$(2) \quad \theta_t - \Delta \theta = \delta f(\bar{x}, \theta)$$

is identified and is examined in some depth. The combustion model (1) leads to the form $f(\bar{x}, \theta) = \exp(\theta)$ for the forcing function f

but generalisations such as $f(\bar{x}, \theta) = \theta^p$, for $p > 1$, are also considered. These models are characterised by the absence of any convective or compressible effects, leading the authors to describe them as "solid," even though solids would also normally be associated with the limit $\beta \rightarrow 0$.

In posing their "gaseous fuel" models, compressibility effects are specifically taken into consideration, leading to different models that may be appropriate under different circumstances. The first model arises for relatively weak effects of compressibility and reduces to the equation

$$(3) \quad \begin{aligned} \theta_t - a \Delta \theta &= \delta e^\theta \\ &+ \frac{\gamma-1}{\gamma} \frac{1}{\text{vol}(\Omega)} \int_{\Omega} \theta_t(\bar{x}, t) d\bar{x}, \end{aligned}$$

in which the constant a may be positive or zero. With stronger effects of compressibility, a reduced Euler model becomes

$$(4) \quad \begin{aligned} \gamma \theta_t - (\gamma-1) P_t &= h e^\theta, \\ \gamma \bar{\nabla} \cdot \bar{v} + P_t &= h e^\theta, \\ \gamma \bar{v}_t + b \bar{\nabla} P &= 0 \end{aligned}$$

for $b > 0$. Finally, a full system is considered, involving conduction, diffusion, convection, viscosity, and reaction.

The common thread that links all of these problems is the phenomenon of *self-ignition* or "*blowup*," the analysis of which in recent years has been due, in no small part, to the authors themselves. Indeed, the title of this book would have described its contents more precisely had the words "blowup" or "ignition" been inserted. The existence, location, and nature of any blowup (as well as the associated existence of any possible steady-state solutions) are rigorously and inexorably examined.

Steady-state solutions of the "solid fuel" model (2) (and, equivalently, the steady version of the "gaseous" model (3) for $a > 0$), with the boundary condition $\theta = 0$ on $\bar{x} \in \partial\Omega$, are the first to come under scrutiny in a variety of geometries and number of dimensions n .

Publishers are invited to send books for review to Professor Nicholas D. Kazarinoff, Department of Mathematics, University of New Mexico, Humanities Building, 4th Floor, Albuquerque, New Mexico 87131 (September 1991–November 1991); Abteilung für Mathematik, Mathematik VI, Universität Ulm, Oberer Eselsberg, D-7900 Ulm, Germany (December 1991–December 1992).

Mathematical Problems From Combustion Theory

**Paul C. Fife, Amable Linan, Forman
Williams**



Mathematical Problems From Combustion Theory:

Mathematical Problems from Combustion Theory Jerrold Bebernes, David Eberly, 2013-12-01 This monograph evolved over the past five years. It had its origin as a set of lecture notes prepared for the Ninth Summer School of Mathematical Physics held at Ravello, Italy, in 1984 and was further refined in seminars and lectures given primarily at the University of Colorado. The material presented is the product of a single mathematical question raised by Dave Kassoy over ten years ago. This question and its partial resolution led to a successful, exciting, almost unique interdisciplinary collaborative scientific effort. The mathematical models described are often times deceptively simple in appearance. But they exhibit a mathematical richness and beauty that belies that simplicity and affirms their physical significance. The mathematical tools required to resolve the various problems raised are diverse and no systematic attempt is made to give the necessary mathematical background. The unifying theme of the monograph is the set of models themselves. This monograph would never have come to fruition without the enthusiasm and drive of Dave Eberly, a former student, now collaborator and coauthor, and without several significant breakthroughs in our understanding of the phenomena of blowup or thermal runaway which certain models discussed possess. A collaborator and former student who has made significant contributions throughout is Alberto Bressan. There are many other collaborators: William Troy, Watson Fulks, Andrew Lacey, Klaus Schmitt, and former students Paul Talaga and Richard Ely, who must be acknowledged and thanked. *A mathematical analysis of some problems from combustion theory* J.W. Bebernes, 1976

The Mathematical Theory of Combustion and Explosions G. Barenblatt, 2011-09-26 vi The amalgamation of individual approaches and results from various schools into a comprehensive scientific theory which can be generally appreciated throughout the international scientific community is often difficult and time-consuming. We believe that one of the best ways to give a complete and clear presentation of a theory is to include a review of the developmental history of that theory. We are convinced that explaining a theory in a historical perspective is essential for a proper understanding of its present state and for a sound choice of future developments. So we have endeavored to present a complete picture of investigations performed in both Western and Soviet nations. We understand that Soviet investigations are less familiar to English-speaking readers due to the language barrier and the obvious sad circumstances of the interruption of scientific connections before and after World War II. Because of this, there is an emphasis on Soviet publications in the bibliography. Our attempt to present a comprehensive picture has made our book rather large because it has had to include some fundamentals of thermochemistry and kinetics as well as self-ignition and flame propagation in various conditions. We have also included stability problems in some detail, but we have had to leave out the problems of combustion of solid propellants and detonation. We hope that our book will be useful to the reader wishing to learn about both the present state of combustion theory and how it originated due to the efforts of many people from different countries. Ya B Z [The Mathematical Theory of Combustion and Explosions](#) G. Barenblatt, 2013-05-14 vi The

amalgamation of individual approaches and results from various schools into a comprehensive scientific theory which can be generally appreciated throughout the international scientific community is often difficult and time consuming. We believe that one of the best ways to give a complete and clear presentation of a theory is to include a review of the developmental history of that theory. We are convinced that explaining a theory in a historical perspective is essential for a proper understanding of its present state and for a sound choice of future developments. So we have endeavored to present a complete picture of investigations performed in both Western and Soviet nations. We understand that Soviet investigations are less familiar to English speaking readers due to the language barrier and the obvious sad circumstances of the interruption of scientific connections before and after World War II. Because of this there is an emphasis on Soviet publications in the bibliography. Our attempt to present a comprehensive picture has made our book rather large because it has had to include some fundamentals of thermochemistry and kinetics as well as self ignition and flame propagation in various conditions. We have also included stability problems in some detail but we have had to leave out the problems of combustion of solid propellants and detonation. We hope that our book will be useful to the reader wishing to learn about both the present state of combustion theory and how it originated due to the efforts of many people from different countries.

Ya B Z *Geometric Sturmian Theory of Nonlinear Parabolic Equations and Applications* Victor A. Galaktionov, 2004-05-24 Unlike the classical Sturm theorems on the zeros of solutions of second order ODEs Sturm's evolution zero set analysis for parabolic PDEs did not attract much attention in the 19th century and in fact it was lost or forgotten for almost a century. Briefly revived by Plya in the 1930s and rediscovered in part several times since it was not until the 1980s that the Sturmian argument for PDEs began to penetrate into the theory of parabolic equations and was found to have several fundamental applications. *Geometric Sturmian Theory of Nonlinear Parabolic Equations and Applications* focuses on geometric aspects of the intersection comparison for nonlinear models creating finite time singularities. After introducing the original Sturm zero set results for linear parabolic equations and the basic concepts of geometric analysis the author presents the main concepts and regularity results of the geometric intersection theory. *G theory*. Here he considers the general singular equation and presents the geometric notions related to the regularity and interface propagation of solutions. In the general setting the author describes the main aspects of the ODE/PDE duality, proves existence and nonexistence theorems, establishes uniqueness and optimal Bernstein type estimates and derives interface equations including higher order equations. The final two chapters explore some special aspects of discontinuous and continuous limit semigroups generated by singular parabolic equations. Much of the information presented here has never before been published in book form. Readable and self contained this book forms a unique and outstanding reference on second order parabolic PDEs used as models for a wide range of physical problems.

Lectures on Combustion Theory Samuel Z. Burstein, Peter D. Lax, Gary A. Sod, 1978 **Two Mathematical Problems Related to the Theory of Combustion** Alberto Bressan, 1982 *Mathematics Applied to Engineering, Modelling, and Social Issues* Frank T.

Smith, Hemen Dutta, John N. Mordeson, 2019-03-14 This book presents several aspects of research on mathematics that have significant applications in engineering modelling and social matters discussing a number of current and future social issues and problems in which mathematical tools can be beneficial Each chapter enhances our understanding of the research problems in a particular area of study and highlights the latest advances made in that area The self contained contributions make the results and problems discussed accessible to readers and provides references to enable those interested to follow subsequent studies in still developing fields Presenting real world applications the book is a valuable resource for graduate students researchers and educators It appeals to general readers curious about the practical applications of mathematics in diverse scientific areas and social problems Transactions of the ... Conference of Army Mathematicians ,1980

Linear Operator Theory in Engineering and Science Arch W. Naylor, George R. Sell, 1982 This book is a unique introduction to the theory of linear operators on Hilbert space The authors goal is to present the basic facts of functional analysis in a form suitable for engineers scientists and applied mathematicians Although the Definition Theorem Proof format of mathematics is used careful attention is given to motivation of the material covered and many illustrative examples are presented First published in 1971 Linear Operator in Engineering and Sciences has since proved to be a popular and very useful textbook Dynamical Issues in Combustion Theory Paul C. Fife, Amable Linan, Foreman Williams, 2012-12-06 This IMA Volume in Mathematics and its Applications DYNAMICAL ISSUES IN COMBUSTION THEORY is based on the proceedings of a workshop which was an integral part of the 1989 90 IMA program on Dynamical Systems and their Applications The aim of this workshop was to cross fertilize research groups working in topics of current interest in combustion dynamics and mathematical methods applicable thereto We thank Shui Nee Chow Martin Golubitsky Richard McGehee George R Sell Paul Fife Amable Liiian and Foreman Williams for organizing the meeting We especially thank Paul Fife Amable Liiilin and Foreman Williams for editing the proceedings We also take this opportunity to thank those agencies whose financial support made the workshop possible the Army Research Office the National Science Foundation and the Office of Naval Research Avner Friedman Willard Miller Jr ix PREFACE The world of combustion phenomena is rich in problems intriguing to the mathematical scientist They offer challenges on several fronts 1 modeling which involves the elucidation of the essential features of a given phenomenon through physical insight and knowledge of experimental results 2 devising appropriate asymptotic and computational methods and 3 developing sound mathematical theories Papers in the present volume which are based on talks given at the Workshop on Dynamical Issues in Combustion Theory in November 1989 describe how all of these challenges have been met for particular examples within a number of common combustion scenarios reactiveshocks low Mach number premixed reactive flow nonpremixed phenomena and solid propellants

MATHEMATICAL MODELS - Volume II Jerzy A. Filar, Jacek B Krawczyk, 2009-09-19 Mathematical Models is a component of Encyclopedia of Mathematical Sciences in the global Encyclopedia of Life Support Systems EOLSS which is an

integrated compendium of twenty one Encyclopedias The Theme on Mathematical Models discusses matters of great relevance to our world such as Basic Principles of Mathematical Modeling Mathematical Models in Water Sciences Mathematical Models in Energy Sciences Mathematical Models of Climate and Global Change Infiltration and Ponding Mathematical Models of Biology Mathematical Models in Medicine and Public Health Mathematical Models of Society and Development These three volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs

Inverse Acoustic and Electromagnetic Scattering Theory David Colton,Raimer Kress,1997-12-11 This book is devoted to the mathematical and numerical analysis of the inverse scattering problem for acoustic and electromagnetic waves The second edition includes material on Newton s method for the inverse obstacle problem an elegant proof of uniqueness for the inverse medium problem a discussion of the spectral theory of the far field operator and a method for determining the support of an inhomogeneous medium from far field data *Transactions of the Twenty-sixth Conference of Army Mathematicians* ,1981 Journal of Mathematical Sciences, the University of Tokyo ,2003 **Theory and Applications of**

Partial Functional Differential Equations Jianhong Wu,1996-09-26 Abstract semilinear functional differential equations arise from many biological chemical and physical systems which are characterized by both spatial and temporal variables and exhibit various spatio temporal patterns The aim of this book is to provide an introduction of the qualitative theory and applications of these equations from the dynamical systems point of view The required prerequisites for that book are at a level of a graduate student The style of presentation will be appealing to people trained and interested in qualitative theory of ordinary and functional differential equations **New Development for Heat Transfer in Solids and Fluid Flow**

Oluwole Daniel Makinde,2017-09-06 Special topic volume with invited peer reviewed papers only Sūgaku Expositions ,2007 **An Introduction to Nonlinear Partial Differential Equations** J. David Logan,1994-04-06 Uses an analytical and techniques oriented approach to present a concise introduction to the subject focusing on time evolution problems Emphasizes hyperbolic and parabolic problems and includes a range of applications chemistry porous media biological problems traffic flow reactors heat transfer and detonation Packed with exercises examples and illustrations

Mathematical Modeling in Combustion and Related Topics Claude-Michel Brauner,Claudine Schmidt-Lainé,2012-12-06 This volume contains invited lectures and contributed papers presented at the NATO Advanced Research Workshop on Mathematical Modeling in Combustion and related topics held in Lyon France April 27 30 1987 This conference was planned to fit in with the two month visit of Professor G S S Ludford to the Ecole Centrale de Lyon He kindly agreed to chair the Scientific and Organizing Committee and actively helped to initiate the meeting His death in December 1986 is an enormous loss to the scientific community in general and in particular to the people involved in the present enterprise The subject of mathematical modeling in combustion is too large for a single conference and the selection of topics reflects both areas of

recent research activity and areas of interest to Professor G S S Ludford to whose memory the Advanced Workshop and this present volume are dedicated The meeting was divided into seven specialized sessions detonation theory mathematical analysis numerical treatment of combustion problems flame theory experimental and industrial aspects complex chemistry and turbulent combustion It brought together researchers and engineers from University and Industry see below the closing remarks of the workshop by Prof N Peters The articles in this volume have been judged and accepted on their scientific quality and language corrections may have been sacrificed in order to allow quick dissemination of knowledge to prevail

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