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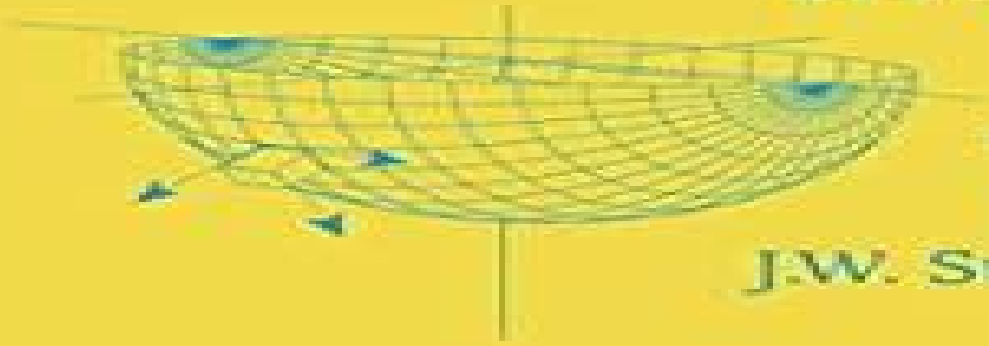
Mathematics of Multidimensional Seismic Imaging, Migration, and Inversion



N. Bleistein
J.K. Cohen
J.W. Stockwell, Jr.

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Mathematics Of Multidimensional Seismic Inversion

Roger M. Samelson,Stephen Wiggins

Mathematics Of Multidimensional Seismic Inversion:

Mathematics of Multidimensional Seismic Imaging, Migration, and Inversion N. Bleistein,J.K. Cohen,John W. Jr. Stockwell,2013-11-22 In the last 40 years geophysicists have found that it is possible to construct images and even determine important physical characteristics of rocks that can yield information about oil and gas bearing structures in the earth To make these images and extract this information requires the application of an advanced understanding of the mathematical physics of wave propagation The oil and gas industry labels a major collection of the necessary seismic data processing methods by the name seismic migration This text ist the first to treat many kinds of migration in a unified mahtematical way The audience is mathematically oriented geophysicists or applied mathematicians working in the field of inverse scattering imaging The text can serve as a bridge between the applied math and geophysics community by presenting geophysicists with a practical introduction to advanced engineering mathematics while presenting mathematicians with a window into the world of the mathematically sophistiated geophysicist **Full-3D Seismic Waveform Inversion** Po Chen,En-Jui Lee,2015-09-10 This book introduces a methodology for solving the seismic inverse problem using purely numerical solutions built on 3D wave equations and which is free of the approximations or simplifications that are common in classical seismic inversion methodologies and therefore applicable to arbitrary 3D geological media and seismic source models Source codes provided allow readers to experiment with the calculations demonstrated and also explore their own applications *Seismic Amplitude Inversion in Reflection Tomography* Yanghua Wang,2003-02-25 This is the first book of its kind on seismic amplitude inversion in the context of reflection tomography The aim of the monograph is to advocate the use of ray amplitude data separately or jointly with traveltime data in reflection seismic tomography The emphasis of seismic exploration is on imaging techniques so that seismic section can be interpreted directly as a geological section In contrast it is perhaps ironic that in decades of industrial seismology one major aspect of waveform data that potentially is easier to measure and analyse has generally been ignored That is the information content of seismic amplitudes Perhaps the potential complexity has deterred most researchers from a more thorough investigation of the practical use of seismic amplitude data The author of this volume presents an authoritative and detailed study of amplitude data as used in conjunction with traveltime data to provide better constraints on the variation of seismic wave speed in the subsurface One of the fundamental problems in conventional reflection seismic tomography using only traveltime data is the possible ambiguity between the velocity variation and the reflector depth The inclusion of amplitude data in the inversion may help to resolve this problem because the amplitudes and traveltimes are sensitive to different features of the subsurface model and thereby provide more accurate information about the subsurface structure and the velocity distribution An essential goal of this monograph is to make the amplitude inversion method work with real reflection seismic data *Inverse Theory and Applications in Geophysics* Michael S. Zhdanov,2015-07-15 Geophysical Inverse Theory and Applications Second Edition brings together fundamental

results developed by the Russian mathematical school in regularization theory and combines them with the related research in geophysical inversion carried out in the West It presents a detailed exposition of the methods of regularized solution of inverse problems based on the ideas of Tikhonov regularization and shows the different forms of their applications in both linear and nonlinear methods of geophysical inversion It s the first book of its kind to treat many kinds of inversion and imaging techniques in a unified mathematical manner The book is divided in five parts covering the foundations of the inversion theory and its applications to the solution of different geophysical inverse problems including potential field electromagnetic and seismic methods Unique in its focus on providing a link between the methods used in gravity electromagnetic and seismic imaging and inversion it represents an exhaustive treatise on inversion theory Written by one of the world s foremost experts this work is widely recognized as the ultimate researcher s reference on geophysical inverse theory and its practical scientific applications Presents state of the art geophysical inverse theory developed in modern mathematical terminology the first to treat many kinds of inversion and imaging techniques in a unified mathematical way Provides a critical link between the methods used in gravity electromagnetic and seismic imaging and inversion and represents an exhaustive treatise on geophysical inversion theory Features more than 300 illustrations figures charts and graphs to underscore key concepts Reflects the latest developments in inversion theory and applications and captures the most significant changes in the field over the past decade **Mathematical and Statistical Methods for Multistatic Imaging** Habib Ammari,Josselin Garnier,Wenjia Jing,Hyeonbae Kang,Mikyoung Lim,Knut Sølna,Han Wang,2013-11-29 This book covers recent mathematical numerical and statistical approaches for multistatic imaging of targets with waves at single or multiple frequencies The waves can be acoustic elastic or electromagnetic They are generated by point sources on a transmitter array and measured on a receiver array An important problem in multistatic imaging is to quantify and understand the trade offs between data size computational complexity signal to noise ratio and resolution Another fundamental problem is to have a shape representation well suited to solving target imaging problems from multistatic data In this book the trade off between resolution and stability when the data are noisy is addressed Efficient imaging algorithms are provided and their resolution and stability with respect to noise in the measurements analyzed It also shows that high order polarization tensors provide an accurate representation of the target Moreover a dictionary matching technique based on new invariants for the generalized polarization tensors is introduced Matlab codes for the main algorithms described in this book are provided Numerical illustrations using these codes in order to highlight the performance and show the limitations of numerical approaches for multistatic imaging are presented *Geophysical Inverse Theory and Regularization Problems* Michael S. Zhdanov,2002-04-24 This book presents state of the art geophysical inverse theory developed in modern mathematical terminology The book brings together fundamental results developed by the Russian mathematical school in regularization theory and combines them with the related research in geophysical inversion carried out in the West It

presents a detailed exposition of the methods of regularized solution of inverse problems based on the ideas of Tikhonov regularization and shows the different forms of their applications in both linear and nonlinear methods of geophysical inversion This text is the first to treat many kinds of inversion and imaging techniques in a unified mathematical manner The book is divided in five parts covering the foundations of the inversion theory and its applications to the solution of different geophysical inverse problems including potential field electromagnetic and seismic methods The first part is an introduction to inversion theory The second part contains a description of the basic methods of solution of the linear and nonlinear inverse problems using regularization The following parts treat the application of regularization methods in gravity and magnetic electromagnetic and seismic inverse problems The key connecting idea of these applied parts of the book is the analogy between the solutions of the forward and inverse problems in different geophysical methods The book also includes chapters related to the modern technology of geophysical imaging based on seismic and electromagnetic migration This volume is unique in its focus on providing a link between the methods used in gravity electromagnetic and seismic imaging and inversion and represents an exhaustive treatise on inversion theory *Waves And Rays In Elastic Continua* Michael A Slawinski,2010-09-09 The present book which is the second and significantly extended edition of the textbook originally published by Elsevier Science emphasizes the interdependence of mathematical formulation and physical meaning in the description of seismic phenomena Herein we use aspects of continuum mechanics wave theory and ray theory to explain phenomena resulting from the propagation of seismic waves The book is divided into three main sections Elastic Continua Waves and Rays and Variational Formulation of Rays There is also a fourth part which consists of appendices In Elastic Continua we use continuum mechanics to describe the material through which seismic waves propagate and to formulate a system of equations to study the behaviour of such a material In Waves and Rays we use these equations to identify the types of body waves propagating in elastic continua as well as to express their velocities and displacements in terms of the properties of these continua To solve the equations of motion in anisotropic inhomogeneous continua we invoke the concept of a ray In Variational Formulation of Rays we show that in elastic continua a ray is tantamount to a trajectory along which a seismic signal propagates in accordance with the variational principle of stationary traveltime Consequently many seismic problems in elastic continua can be conveniently formulated and solved using the calculus of variations In the Appendices we describe two mathematical concepts that are used in the book namely homogeneity of a function and Legendre s transformation This section also contains a list of symbols *Statistical Methods of Geophysical Data Processing* Vladimir Troyan,Yurii Kiselev,2010 This textbook contains a consideration of the wide field of problems connected with statistical methods of processing of observed data with the main examples and considered models related to geophysics and seismic exploration This textbook will be particularly helpful to students and professionals from various fields of physics connected with an estimation of the parameters of the physical objects by experimental data The reader can also find many important

topics which are the basis for statistical methods of estimation and inverse problem solutions Inverse Problems and Imaging Luis L. Bonilla,2009-06-19 Nowadays we are facing numerous and important imaging problems nondestructive testing of materials monitoring of industrial processes enhancement of oil production by efficient reservoir characterization emerging developments in noninvasive imaging techniques for medical purposes computerized tomography CT magnetic resonance imaging MRI positron emission tomography PET X ray and ultrasound tomography etc In the CIME Summer School on Imaging Martina Franca Italy 2002 leading experts in mathematical techniques and applications presented broad and useful introductions for non experts and practitioners alike to many aspects of this exciting field The volume contains part of the above lectures completed and updated by additional contributions on other related topics **Multi-wave Medical Imaging: Mathematical Modelling And Imaging Reconstruction** Hyeonbae Kang,Loc Hoang Nguyen,Laurent Seppecher,2017-03-03 Super Resolution imaging refers to modern techniques of achieving resolution below conventional limits This book gives a comprehensive overview of mathematical and computational techniques used to achieve this providing a solid foundation on which to develop the knowledge and skills needed for practical application of techniques Split into five parts the first looks at the mathematical and probabilistic tools needed before moving on to description of different types of imaging single wave anomaly multi wave and spectroscopic and nanoparticle As an important contribution to the understanding of super resolution techniques in biomedical imaging this book is a useful resource for scientists and engineers in the fields of biomedical imaging and super resolution and is self contained reference for any newcomers to these fields Advances in Geophysics Ru-Shan Wu,Valerie Maupin,2006-12-14 Significant progress in our understanding of the Earth s structure and functioning is dependent on new and original observations However these observations cannot be interpreted in a quantitative way without tools to model them and developing adequate modelling methods is also a prerequisite for progress Seismological raw data in the 21st century are mostly three component broadband recordings and require advanced numerical tools to be modelled especially if lateral variations in the model are accounted for in addition to the radial stratification of the Earth Considerable progress has been made concerning modelling of elastic waves in laterally heterogeneous structures in the last decades taking advantage of the development of computer power The number of articles related to new developments of diverse methods is enormous and it can be very difficult for newcomers to get an overview of the different methods available and to be able to find which method is most appropriate for his or her applications This book aims at giving introductions and basic reviews of the modelling methods for elastic waves in laterally heterogeneous structures which are most commonly used in contemporary seismology or may have great potential for the future

Fundamentals of Ultrasonic Phased Arrays Lester W. Schmerr Jr.,2014-08-13 This book describes in detail the physical and mathematical foundations of ultrasonic phased array measurements The book uses linear systems theory to develop a comprehensive model of the signals and images that can be formed with phased arrays Engineers working in the

field of ultrasonic nondestructive evaluation NDE will find in this approach a wealth of information on how to design optimize and interpret ultrasonic inspections with phased arrays The fundamentals and models described in the book will also be of significant interest to other fields including the medical ultrasound and seismology communities A unique feature of this book is that it presents a unified theory of imaging with phased arrays that shows how common imaging methods such as the synthetic aperture focusing technique SAFT the total focusing method TFM and the physical optics far field inverse scattering POFFIS imaging method are all simplified versions of more fundamental and quantitative imaging approaches called imaging measurement models To enhance learning this book first describes the fundamentals of phased array systems using 2 D models so that the complex 3 D cases normally found in practice can be more easily understood In addition to giving a detailed discussion of phased array systems Fundamentals of Ultrasonic Phased Arrays also provides MATLAB functions and scripts allowing the reader to conduct simulations of ultrasonic phased array transducers and phased array systems with the latest modeling technology **An Invitation to 3-D Vision** Yi Ma,Stefano Soatto,Jana Kosecká,S. Shankar Sastry,2012-11-06 This book is intended to give students at the advanced undergraduate or introduc tory graduate level and researchers in computer vision robotics and computer graphics a self contained introduction to the geometry of three dimensional 3 D vision This is the study of the reconstruction of 3 D models of objects from a collection of 2 D images An essential prerequisite for this book is a course in linear algebra at the advanced undergraduate level Background knowledge in rigid body motion estimation and optimization will certainly improve the reader s appreciation of the material but is not critical since the first few chapters and the appendices provide a review and summary of basic notions and results on these topics Our motivation Research monographs and books on geometric approaches to computer vision have been published recently in two batches The first was in the mid 1990s with books on the geometry of two views see e g Faugeras 1993 Kanatani 1993b Maybank 1993 Weng et aI 1993b The second was more recent with books fo cusing on the geometry of multiple views see e g Hartley and Zisserman 2000 and Faugeras and Luong 2001 as well as a more comprehensive book on computer vision Forsyth and Ponce 2002 We felt that the time was ripe for synthesizing the material in a unified framework so as to provide a self contained exposition of this subject which can be used both for pedagogical purposes and by practitioners interested in this field **Nonlinear Systems** Shankar Sastry,2013-04-18 There has been a great deal of excitement in the last ten years over the emer gence of new mathematical techniques for the analysis and control of nonlinear systems Witness the emergence of a set of simplified tools for the analysis of bifurcations chaos and other complicated dynamical behavior and the develop ment of a comprehensive theory of geometric nonlinear control Coupled with this set of analytic advances has been the vast increase in computational power available for both the simulation and visualization of nonlinear systems as well as for the implementation in real time of sophisticated real time nonlinear control laws Thus technological advances havebolstered the impact of analytic advances and produced a tremendous variety of new

problems and applications that are nonlinear in an essential way Nonlinear controllaws have been implemented for sophisticated flight control systems on board helicopters and vertical take offand landing aircraft adaptive nonlinearcontrollaws havebeen implementedfor robot manipulators operating either singly or in cooperation on a multi fingered robot hand adaptive control laws have been implemented forjetengines andautomotive fuel injection systems as well as for automated highway systems and air traffic management systems to mention a few examples Bifurcation theory has been used to explain and understand the onset of fiutterin the dynamics of aircraft wing structures the onset of oscillations in nonlinear circuits surge and stall in aircraft engines voltage collapse in a power transmission network **The Geometry of Biological Time** Arthur T. Winfree,2013-03-09 Geometry of Biological Time deals with dynamics of processes that repeat themselves regularly Such rhythmic return through a cycle of change is an ubiquitous principle of organization in living systems In this revised and updated edition the author plans to extend the thread from 1980 to the present concentrating on areas which he personally feels have been interesting and where he feels there will be much activity in the future This involves going through spatial biochemical electrophysiological and organismic dynamical systems and patterns that were discovered by pursuing the theme of phase singularities that the original book introduced In particular the work on excitability in cell membranes has been thoroughly updated as have the references throughout the book **Lagrangian Transport in Geophysical Jets and Waves** Roger M. Samelson,Stephen Wiggins,2006-11-24 The purpose of this book is to provide an accessible introduction to a new set of methods for the analysis of Lagrangian motion in geophysical ows These methods were originally developed in the abstract mathem ical setting of dynamical systems theory through a geometric approach to di erential equations that ultimately owes much to the insights of Poincar e 1892 In the 1980s and 1990s researchers in applied mathematics and uid dynamics recognized the potential of this approach for the analysis of uid motion Despite these developments and the existence of a substantial body of work on geophysical uid problems in the dynamical systems and geophysicalliterature nointroductorytexthasbeenavailablethatpresents these methods in the context of geophysical uid ow The text is meant to be accessible to geophysical uid scientists and students familiar with the mathematics of ordinary mostly and partial sometimes di erential equations It assumes little or no prior knowledge of dynamical systems theory An e ort is made to explain concepts from a physical point of view and to avoid the theorem and proof constructions that appear in dynamical systems texts We hope that this book will prove usefultograduatestudents researchscientists andeducatorsinanybranch of geophysical uid science in which the motion and transport of uid and ofmaterialscarriedbythe uid isofinterest Wehopethatitwillalsoprove interesting and useful to applied mathematicians who seek an introduction to an intriguing and rapidly developing area of geophysical uid dynamics Random Heterogeneous Materials Salvatore Torquato,2013-04-17 The interdisciplinary subject of random heterogeneous materials has experienced remarkable growth since the publication of the well known monograph Statistical Con tinuum Theories by Beran 1968 Many

of these advances especially those concerning the statistical characterization of the microstructure and its effect on the physical prop erties of the material have not been treated fully in any book One of the intents of the present book is to fill this gap This book also distinguishes itself in that it provides a unified rigorous framework to characterize the microstructures and macroscopic properties of the widely diverse types of heterogeneous materials found in nature and synthetic products Emphasis is placed on providing foundational theoretical methods that can simultaneously yield results of practical utility This book treats a wide breadth of topics but the choice of subjects naturally reflects my own interests The sheer enormity of the field has prevented me from covering many important topics I apologize to those colleagues known and unknown who may not find enough of their own work cited in the ensuing pages *Mathematical Physiology* James Keener,James Sneyd,2009-01-06 Divided into two volumes the book begins with a pedagogical presentation of some of the basic theory with chapters on biochemical reactions diffusion excitability wave propagation and cellular homeostasis The second more extensive part discusses particular physiological systems with chapters on calcium dynamics bursting oscillations and secretion cardiac cells muscles intercellular communication the circulatory system the immune system wound healing the respiratory system the visual system hormone physiology renal physiology digestion the visual system and hearing New chapters on Calcium Dynamics Neuroendocrine Cells and Regulation of Cell Function have been included Mathematical Population Genetics 1 Warren J. Ewens,2012-10-01 Population genetics occupies a central role in a number of important biological and social undertakings It is fundamental to our understanding of evolutionary processes of plant and animal breeding programs and of various diseases of particular importance to mankind This is the first of a planned two volume work discussing the mathematical aspects of population genetics with an emphasis on the evolutionary theory This first volume draws heavily from the author s classic 1979 edition which appeared originally in Springer s Biomathematics series It has been revised and expanded to include recent topics which follow naturally from the treatment in the earlier edition e g the theory of molecular population genetics This book will appeal to graduate students and researchers in mathematical biology and other mathematically trained scientists looking to enter the field of population genetics *Geometry and Topology in Hamiltonian Dynamics and Statistical Mechanics* Marco Pettini,2007-06-14 Itisaspecialpleasureformetowritethisforewordforaremarkablebookbya remarkableauthor MarcoPettiniisadeepthinker whohasspentmanyyears probing the foundations of Hamiltonian chaos and statistical mechanics in particular phase transitions from the point of view of geometry and topology Itisinparticularthequalityofmindoftheauthorandhisdeepphysical as well as mathematical insights which make this book so special and inspiring It is a must for those who want to venture into a new approach to old problems or want to use new tools for new problems Although topology has penetrated a number of elds of physics a broad participationoftopologyintheclari cationandprogressoffundamentalpr lems in the above mentioned elds has been lacking The new perspectives topology gives to the above mentioned problems are bound to help in their clari

cation and to spread to other elds of science The sparsity of geometric thinking and of its use to solve fundamental problems when compared with purely analytical methods in physics could be relieved and made highly productive using the material discussed in this book It is unavoidable that the physicist reader may have then to learn some new mathematics and be challenged to a new way of thinking but with the author as a guide he is assured of the best help in achieving this that is presently available

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Mathematics Of Multidimensional Seismic Inversion Introduction

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