

THE IMA VOLUMES IN MATHEMATICS  
AND ITS APPLICATIONS

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**Geometric  
Methods in  
Inverse  
Problems and  
PDE Control**



Springer

# Geometric Methods In Inverse Problems And Pde Control

**Minjie Lin**



## **Geometric Methods In Inverse Problems And Pde Control:**

*Geometric Methods in Inverse Problems and Pde Control* Christopher B Croke, Gunther Uhlmann, Irena Lasiecka, 2004-02-26      **Geometric Methods in Inverse Problems and PDE Control** Christopher B. Croke, Gunther Uhlmann, Irena Lasiecka, Michael Vogelius, 2012-12-06 This IMA Volume in Mathematics and its Applications GEOMETRIC METHODS IN INVERSE PROBLEMS AND PDE CONTROL contains a selection of articles presented at 2001 IMA Summer Program with the same title We would like to thank Christopher B Croke University of Penn sylv nia Irena Lasiecka University of Virginia Gunther Uhlmann University of Washington and Michael S Vogelius Rutgers University for their excellent work as organizers of the two week summer workshop and for editing the volume We also take this opportunity to thank the National Science Foundation for their support of the IMA Series Editors Douglas N Arnold Director of the IMA Fadil Santosa Deputy Director of the IMA v PREFACE This volume contains a selected number of articles based on lectures delivered at the IMA 2001 Summer Program on Geometric Methods in Inverse Problems and PDE Control The focus of this program was some common techniques used in the study of inverse coefficient problems and control problems for partial differential equations with particular emphasis on their strong relation to fundamental problems of geometry Inverse coefficient problems for partial differential equations arise in many application areas for instance in medical imaging nondestructive testing and geophysical prospecting Control problems involving partial differential equations may arise from the need to optimize a given performance criterion e g to dampen out undesirable vibrations of a structure or more generally to obtain a prescribed behaviour of the dynamics      **New Analytic and Geometric Methods in Inverse Problems** Kenrick Bingham, Yaroslav V. Kurylev, E. Somersalo, 2013-04-17 In inverse problems the aim is to obtain via a mathematical model information on quantities that are not directly observable but rather depend on other observable quantities Inverse problems are encountered in such diverse areas of application as medical imaging remote sensing material testing geosciences and financing It has become evident that new ideas coming from differential geometry and modern analysis are needed to tackle even some of the most classical inverse problems This book contains a collection of presentations written by leading specialists aiming to give the reader up to date tools for understanding the current developments in the field

**Functional Analysis and Evolution Equations** Herbert Amann, Wolfgang Arendt, Frank Neubrander, Serge Nicaise, Joachim Below, 2008-02-28 Gunter Lumer was an outstanding mathematician whose works have great influence on the research community in mathematical analysis and evolution equations He was at the origin of the breath taking development the theory of semigroups saw after the pioneering book of Hille and Phillips from 1957 This volume contains invited contributions presenting the state of the art of these topics and reflecting the broad interests of Gunter Lumer

Symmetric Functionals on Random Matrices and Random Matchings Problems Grzegorz Rempala, Jacek Wesolowski, 2007-12-06 This IMA Volume in Mathematics and its Applications SYMMETRIC FUNCTIONALS ON RANDOM

**MATRICES AND RANDOM MATCHINGS PROBLEMS** During the academic year 2003 2004 the Institute for Mathematics and its Applications IMA held a thematic program on Probability and Statistics in Complex Systems The program focused on large complex systems in which stochasticity plays a significant role Such systems are very diverse and the IMA program emphasized systems as varied as the human genome the internet and world financial markets Although quite different these systems have features in common such as multitudes of interconnecting parts and the availability of large amounts of high dimensional noisy data The program emphasized the development and application of common mathematical and computational techniques to model and analyze such systems About 1 000 mathematicians statisticians scientists and engineers participated in the IMA thematic program including about 50 who were in residence at the IMA during much or all of the year The present volume was born during the 2003 2004 thematic program at the IMA The two authors were visitors to the IMA during the program year with the first author resident for the entire ten months This volume is a result of the authors interactions at the IMA and especially their discussions with the many other program participants in the program and their involvement in the numerous tutorials workshops and seminars held during the year

**Geometry of the Generalized Geodesic Flow and Inverse Spectral Problems** Vesselin M. Petkov, Luchezar N. Stoyanov, 2017-01-30 This book is a new edition of a title originally published in 1992 No other book has been published that treats inverse spectral and inverse scattering results by using the so called Poisson summation formula and the related study of singularities This book presents these in a closed and comprehensive form and the exposition is based on a combination of different tools and results from dynamical systems microlocal analysis spectral and scattering theory The content of the first edition is still relevant however the new edition will include several new results established after 1992 new text will comprise about a third of the content of the new edition The main chapters in the first edition in combination with the new chapters will provide a better and more comprehensive presentation of importance for the applications inverse results These results are obtained by modern mathematical techniques which will be presented together in order to give the readers the opportunity to completely understand them Moreover some basic generic properties established by the authors after the publication of the first edition establishing the wide range of applicability of the Poisson relation will be presented for first time in the new edition of the book

*Representation and Control of Infinite Dimensional Systems* Alain Bensoussan, Giuseppe Da Prato, Michel C. Delfour, Sanjoy K. Mitter, 2007-04-05 This unified revised second edition of a two volume set is a self contained account of quadratic cost optimal control for a large class of infinite dimensional systems The original editions received outstanding reviews yet this new edition is more concise and self contained New material has been added to reflect the growth in the field over the past decade There is a unique chapter on semigroup theory of linear operators that brings together advanced concepts and techniques which are usually treated independently The material on delay systems and structural operators has not yet appeared anywhere in book form

**Control Theory of Partial Differential Equations** Guenter Leugering, Oleg

Imanuvilov, Bing-Yu Zhang, Roberto Triggiani, 2005-05-27 The field of control theory in PDEs has broadened considerably as more realistic models have been introduced and investigated This book presents a broad range of recent developments new discoveries and mathematical tools in the field The authors discuss topics such as elasticity thermo elasticity aero elasticity interactions between fluids a Mixed Integer Nonlinear Programming Jon Lee, Sven Leyffer, 2011-12-02 Many engineering operations and scientific applications include a mixture of discrete and continuous decision variables and nonlinear relationships involving the decision variables that have a pronounced effect on the set of feasible and optimal solutions Mixed integer nonlinear programming MINLP problems combine the numerical difficulties of handling nonlinear functions with the challenge of optimizing in the context of nonconvex functions and discrete variables MINLP is one of the most flexible modeling paradigms available for optimization but because its scope is so broad in the most general cases it is hopelessly intractable Nonetheless an expanding body of researchers and practitioners including chemical engineers operations researchers industrial engineers mechanical engineers economists statisticians computer scientists operations managers and mathematical programmers are interested in solving large scale MINLP instances Symmetries and Overdetermined Systems of Partial Differential Equations Michael Eastwood, Willard Miller, 2009-04-23 This three week summer program considered the symmetries preserving various natural geometric structures There are two parts to the proceedings The articles in the first part are expository but all contain significant new material The articles in the second part are concerned with original research All articles were thoroughly refereed and the range of interrelated work ensures that this will be an extremely useful collection **Time Series Analysis and Applications to Geophysical Systems** David Brillinger, Peter Caines, John Geweke, Emanuel Parzen, Murray Rosenblatt, Murad S. Taqqu, 2012-12-06 Part of a two volume set based on a recent IMA program of the same name The goal of the program and these books is to develop a community of statistical and other scientists kept up to date on developments in this quickly evolving and interdisciplinary field Consequently these books present recent material by distinguished researchers Topics discussed in Part I include nonlinear and non Gaussian models and processes higher order moments and spectra nonlinear systems applications in astronomy geophysics engineering and simulation and the interaction of time series analysis and statistics information model identification categorical valued time series nonparametric and semiparametric methods Self similar processes and long range dependence time series with long memory fractals 1 f noise stable noise and time series research common to engineers and economists modeling of multivariate and possibly non stationary time series state space and adaptive methods are discussed in Part II

**Mathematical Approaches for Emerging and Reemerging Infectious Diseases: An Introduction** Carlos Castillo-Chavez, 2002-05-02 This book grew out of the discussions and presentations that began during the Workshop on Emerging and Reemerging Diseases May 17 21 1999 sponsored by the Institute for Mathematics and its Application IMA at the University of Minnesota with the support of NIH and NSF The workshop started with a two day tutorial session directed

at ecologists epidemiologists immunologists mathematicians and scientists interested in the study of disease dynamics The core of this first volume Volume 125 covers tutorial and research contributions on the use of dynamical systems deterministic discrete delay PDEs and ODEs models and stochastic models in disease dynamics The volume includes the study of cancer HIV pertussis and tuberculosis Beginning graduate students in applied mathematics scientists in the natural social or health sciences or mathematicians who want to enter the fields of mathematical and theoretical epidemiology will find this book useful

**Modeling of Soft Matter** Maria-Carme T. Calderer, Eugene M. Terentjev, 2008-08-26 This IMA Volume in Mathematics and its Applications MODELING OF SOFT MATTER contains papers presented at a very successful workshop with the same title The event which was held on September 27 October 1 2004 was an integral part of the 2004 2005 IMA Thematic Year on Mathematics of Materials and Macromolecules Multiple Scales Disorder and Singularities We would like to thank Maria Carme T Calderer School of Mathematics University of Minnesota and Eugene M Terentjev Cavendish Laboratory University of Cambridge for their superb role as workshop organizers and editors of the proceedings We take this opportunity to thank the National Science Foundation for its support of the IMA Series Editors Douglas N Arnold Director of the IMA Arnd Scheel Deputy Director of the IMA

**PREFACE** The physics of soft matter in particular focusing on such materials as complex fluids liquid crystals elastomers soft ferroelectrics foams gels and particulate systems is an area of intense interest and contemporary study Soft matter plays a role in a wide variety of important processes and application as well as in living systems For example gel swelling is an essential part of many biological processes such as motility mechanisms in bacteria and the transport and absorption of drugs Ferroelectrics liquid crystals and elastomers are being used to design ever faster switching devices Experiments of the last decade have provided a great deal of detailed information on structures and properties of soft matter

**Dispersive Transport Equations and Multiscale Models** Ben Abdallah Naoufel, Anton Arnold, Pierre Degond, Irene M. Gamba, Robert T. Glassey, C. David Levermore, Christian Ringhofer, 2012-12-06 IMA Volumes 135 Transport in Transition Regimes and 136 Dispersive Transport Equations and Multiscale Models focus on the modeling of processes for which transport is one of the most complicated components This includes processes that involve a wide range of length scales over different spatio-temporal regions of the problem ranging from the order of mean free paths to many times this scale Consequently effective modeling techniques require different transport models in each region The first issue is that of finding efficient simulations techniques since a fully resolved kinetic simulation is often impractical One therefore develops homogenization stochastic or moment based subgrid models Another issue is to quantify the discrepancy between macroscopic models and the underlying kinetic description especially when dispersive effects become macroscopic for example due to quantum effects in semiconductors and superfluids These two volumes address these questions in relation to a wide variety of application areas such as semiconductors plasmas fluids chemically reactive gases etc

Atmospheric Modeling David P. Chock, Gregory R. Carmichael, 2002-07-31 This volume contains refereed papers

submitted by international experts who participated in the Atmospheric Modeling workshop March 15-19 2000 at the Institute for Mathematics and Its Applications IMA at the University of Minnesota. The papers cover a wide range of topics presented in the workshop. In particular, mathematical topics include a performance comparison of operator splitting and non-splitting methods, time-stepping methods to preserve positivity, and consideration of multiple timescale issues in the modeling of atmospheric chemistry, a fully 3D adaptive grid method, impact of grid resolution on model predictions, testing the robustness of different flow fields, modeling and numerical methods in four-dimensional variational data assimilation, and parallel computing. Modeling topics include the development of an efficient self-contained global circulation chemistry transport model and its applications, the development of a modal aerosol model, and the modeling of the emissions and chemistry of monoterpenes that lead to the formation of secondary organic aerosols. The volume provides an excellent cross-section of current research activities in atmospheric modeling.

Multiple-Time-Scale Dynamical Systems Christopher K.R.T. Jones, Alexander I. Khibnik, 2012-12-06. Systems with sub-processes evolving on many different time scales are ubiquitous in applications: chemical reactions, electro-optical, and neuro-biological systems, to name just a few. This volume contains papers that expose the state of the art in mathematical techniques for analyzing such systems. Recently developed geometric ideas are highlighted in this work, that includes a theory of relaxation-oscillation phenomena in higher-dimensional phase spaces. Subtle exponentially small effects result from singular perturbations implicit in certain multiple time-scale systems. Their role in the slow motion of fronts, bifurcations, and jumping between invariant tori are all explored here. Neurobiology has played a particularly stimulating role in the development of these techniques, and one paper is directed specifically at applying geometric singular perturbation theory to reveal the synchrony in networks of neural oscillators.

**Mathematics of the Internet** Brenda Dietrich, Rakesh V. Vohra, Patricia Brick, 2001-12-14. The use of the internet for commerce has spawned a variety of auctions, marketplaces, and exchanges for trading everything from bandwidth to books. Mechanisms for bidding, agents, dynamic pricing, and combinatorial bids are being implemented in support of internet-based auctions, giving rise to new versions of optimization and resource allocation models. This volume, a collection of papers from an IMA Hot Topics workshop in internet auctions, includes descriptions of real and proposed auctions, complete with mathematical model formulations, theoretical results, solution approaches, and computational studies. This volume also provides a mathematical programming perspective on open questions in auction theory and provides a glimpse of the growing area of dynamic pricing.

*Compatible Spatial Discretizations* Douglas N. Arnold, Pavel B. Bochev, Richard B. Lehoucq, Roy A. Nicolaides, Mikhail Shashkov, 2007-01-26. The IMA Hot Topics workshop on compatible spatial discretizations was held in 2004. This volume contains original contributions based on the material presented there. A unique feature is the inclusion of work that is representative of the recent developments in compatible discretizations across a wide spectrum of disciplines in computational science. Abstracts and presentation slides from the workshop can be accessed on the internet.

*Towards Higher Categories* John C. Baez, J. Peter May, 2009-09-24 The purpose of this book is to give background for those who would like to delve into some higher category theory It is not a primer on higher category theory itself It begins with a paper by John Baez and Michael Shulman which explores informally by analogy and direct connection how cohomology and other tools of algebraic topology are seen through the eyes of  $n$  category theory The idea is to give some of the motivations behind this subject There are then two survey articles by Julie Bergner and Simona Paoli about infinity 1 categories and about the algebraic modelling of homotopy  $n$  types These are areas that are particularly well understood and where a fully integrated theory exists The main focus of the book is on the richness to be found in the theory of bicategories which gives the essential starting point towards the understanding of higher categorical structures An article by Stephen Lack gives a thorough but informal guide to this theory A paper by Larry Breen on the theory of gerbes shows how such categorical structures appear in differential geometry This book is dedicated to Max Kelly the founder of the Australian school of category theory and an historical paper by Ross Street describes its development

*Computational Modeling in Biological Fluid Dynamics* Lisa J. Fauci, Shay Gueron, 2012-12-06 This IMA Volume in Mathematics and its Applications COMPUTATIONAL MODELING IN BIOLOGICAL FLUID DYNAMICS is based on the proceedings of a very successful workshop with the same title The workshop was an integral part of the September 1998 to June 1999 IMA program on MATHEMATICS IN BIOLOGY I would like to thank the organizing committee Lisa J Fauci of Tulane University and Shay Gueron of Technion Israel Institute of Technology for their excellent work as organizers of the meeting and for editing the proceedings I also take this opportunity to thank the National Science Foundation NSF whose financial support of the IMA made the Mathematics in Biology program possible Willard Miller Jr Professor and Director Institute for Mathematics and its Applications University of Minnesota 400 Lind Hall 207 Church St SE Minneapolis MN 55455 0436 612 624 6066 FAX 612 626 7370 miller@ima.umn.edu World Wide Web <http://www.ima.umn.edu>

PREFACE A unifying theme in biological fluid dynamics is the interaction of moving elastic boundaries with a surrounding fluid A complex dynamical system describes the motion of red blood cells through the circulatory system the movement of spermatazoa in the reproductive tract cilia of microorganisms or a heart pumping blood The revolution in computational technology has allowed tremendous progress in the study of these previously intractable fluid structure interaction problems



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