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Fioralba Cakoni
David Colton

A Qualitative Approach to Inverse Scattering Theory



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A Qualitative Approach to Inverse Scattering Theory Fioralba Cakoni, David Colton, 2013-10-28 Inverse scattering theory is an important area of applied mathematics due to its central role in such areas as medical imaging nondestructive testing and geophysical exploration Until recently all existing algorithms for solving inverse scattering problems were based on using either a weak scattering assumption or on the use of nonlinear optimization techniques The limitations of these methods have led in recent years to an alternative approach to the inverse scattering problem which avoids the incorrect model assumptions inherent in the use of weak scattering approximations as well as the strong a priori information needed in order to implement nonlinear optimization techniques These new methods come under the general title of qualitative methods in inverse scattering theory and seek to determine an approximation to the shape of the scattering object as well as estimates on its material properties without making any weak scattering assumption and using essentially no a priori information on the nature of the scattering object This book is designed to be an introduction to this new approach in inverse scattering theory focusing on the use of sampling methods and transmission eigenvalues In order to aid the reader coming from a discipline outside of mathematics we have included background material on functional analysis Sobolev spaces the theory of ill posed problems and certain topics in the theory of entire functions of a complex variable This book is an updated and expanded version of an earlier book by the authors published by Springer titled Qualitative Methods in Inverse Scattering Theory Review of Qualitative Methods in Inverse Scattering Theory All in all the authors do exceptionally well in combining such a wide variety of mathematical material and in presenting it in a well organized and easy to follow fashion This text certainly complements the growing body of work in inverse scattering and should well suit both new researchers to the field as well as those who could benefit from such a nice codified collection of profitable results combined in one bound volume SIAM Review 2006

Inverse Scattering Theory and Transmission Eigenvalues Fioralba Cakoni, David Colton, Housseem Haddar, 2022-12-07 Inverse scattering theory is a major theme in applied mathematics with applications to such diverse areas as medical imaging geophysical exploration and nondestructive testing The inverse scattering problem is both nonlinear and ill posed thus presenting challenges in the development of efficient inversion algorithms A further complication is that anisotropic materials cannot be uniquely determined from given scattering data In the first edition of Inverse Scattering Theory and Transmission Eigenvalues the authors discussed methods for determining the support of inhomogeneous media from measured far field data and the role of transmission eigenvalue problems in the mathematical development of these methods In this second edition three new chapters describe recent developments in inverse scattering theory In particular the authors explore the use of modified background media in the nondestructive testing of materials and methods for determining the modified transmission eigenvalues that arise in such applications from measured far field data They also examine nonscattering wave numbers a subset of transmission eigenvalues using techniques taken from the theory

of free boundary value problems for elliptic partial differential equations and discuss the dualism of scattering poles and transmission eigenvalues that has led to new methods for the numerical computation of scattering poles This book will be of interest to research mathematicians and engineers and physicists working on problems in target identification It will also be useful to advanced graduate students in many areas of applied mathematics

Qualitative Methods in Inverse Scattering Theory Fioralba Cakoni, David Colton, 2005-12-29 Inverse scattering theory has been a particularly active and successful field in applied mathematics and engineering for the past twenty years The increasing demands of imaging and target identification require new powerful and flexible techniques besides the existing weak scattering approximation or nonlinear optimization methods One class of such methods comes under the general description of qualitative methods in inverse scattering theory This textbook is an easily accessible class tested introduction to the field It is accessible also to readers who are not professional mathematicians thus making these new mathematical ideas in inverse scattering theory available to the wider scientific and engineering community

Qualitative Methods in Inverse Scattering Theory Fioralba Cakoni, David Colton, 2005-11-03 Inverse scattering theory has been a particularly active and successful field in applied mathematics and engineering for the past twenty years The increasing demands of imaging and target identification require new powerful and flexible techniques besides the existing weak scattering approximation or nonlinear optimization methods One class of such methods comes under the general description of qualitative methods in inverse scattering theory This textbook is an easily accessible class tested introduction to the field It is accessible also to readers who are not professional mathematicians thus making these new mathematical ideas in inverse scattering theory available to the wider scientific and engineering community

Parameter Estimation of Nonlinear Random Medium by Scattered Electromagnetic Fields Manisha Khulbe, Harish Parthasarathy, 2023-10-16 This book is on the nonlinear random medium analysis that includes subtopics of terahertz imaging inverse scattering plasmonics quantum optics communication laser modes and terahertz photonic antennas Here in this book a mathematical framework is developed to analyze the impact of dimensions and chemical potential on nano antenna channels

Fourier Series, Fourier Transform and Their Applications to Mathematical Physics Valery Serov, 2017-11-26 This text serves as an introduction to the modern theory of analysis and differential equations with applications in mathematical physics and engineering sciences Having outgrown from a series of half semester courses given at University of Oulu this book consists of four self contained parts The first part Fourier Series and the Discrete Fourier Transform is devoted to the classical one dimensional trigonometric Fourier series with some applications to PDEs and signal processing The second part Fourier Transform and Distributions is concerned with distribution theory of L Schwartz and its applications to the Schrödinger and magnetic Schrödinger operations The third part Operator Theory and Integral Equations is devoted mostly to the self adjoint but unbounded operators in Hilbert spaces and their applications to integral equations in such spaces The fourth and final part Introduction to Partial Differential Equations

serves as an introduction to modern methods for classical theory of partial differential equations Complete with nearly 250 exercises throughout this text is intended for graduate level students and researchers in the mathematical sciences and engineering

Numerical Methods for Inverse Scattering Problems Jingzhi Li,Hongyu Liu,2023-09-07 This book highlights the latest developments on the numerical methods for inverse scattering problems associated with acoustic electromagnetic and elastic waves Inverse scattering problems are concerned with identifying unknown or inaccessible objects by wave probing data which makes possible many industrial and engineering applications including radar and sonar medical imaging nondestructive testing remote sensing and geophysical exploration The mathematical study of inverse scattering problems is an active field of research This book presents a comprehensive and unified mathematical treatment of various inverse scattering problems mainly from a numerical reconstruction perspective It highlights the collaborative research outputs by the two groups of the authors yet surveys and reviews many existing results by global researchers in the literature The book consists of three parts respectively corresponding to the studies on acoustic electromagnetic and elastic scattering problems In each part the authors start with in depth theoretical and computational treatments of the forward scattering problems and then discuss various numerical reconstruction schemes for the associated inverse scattering problems in different scenarios of practical interest In addition the authors provide an overview of the existing results in the literature by other researchers This book can serve as a handy reference for researchers or practitioners who are working on or implementing inverse scattering methods It can also serve as a graduate textbook for research students who are interested in working on numerical algorithms for inverse scattering problems

Inverse Scattering Problems and Their Application to Nonlinear Integrable Equations Pham Loi Vu,2019-11-11 Inverse Scattering Problems and Their Application to Nonlinear Integrable Equations is devoted to inverse scattering problems ISPs for differential equations and their application to nonlinear evolution equations NLEEs The book is suitable for anyone who has a mathematical background and interest in functional analysis partial differential equations equations of mathematical physics and functions of a complex variable This book is intended for a wide community working with inverse scattering problems and their applications in particular there is a traditional community in mathematical physics In this monograph the problems are solved step by step and detailed proofs are given for the problems to make the topics more accessible for students who are approaching them for the first time Features The unique solvability of ISPs are proved The scattering data of the considered inverse scattering problems ISPs are described completely Solving the associated initial value problem or initial boundary value problem for the nonlinear evolution equations NLEEs is carried out step by step Namely the NLEE can be written as the compatibility condition of two linear equations The unknown boundary values are calculated with the help of the Lax generalized equation and then the time dependent scattering data SD are constructed from the initial and boundary conditions The potentials are recovered uniquely in terms of time dependent SD and the solution of the NLEEs is expressed uniquely in terms of the found solutions

of the ISP Since the considered ISPs are solved well then the SPs generated by two linear equations constitute the inverse scattering method ISM The application of the ISM to solving the NLEEs is consistent and is effectively embedded in the schema of the ISM

Maxwell Equation: Inverse Scattering In Electromagnetism Hiroshi Isozaki, 2018-07-12 How can one determine the physical properties of the medium or the geometrical properties of the domain by observing electromagnetic waves To answer this fundamental problem in mathematics and physics this book leads the reader to the frontier of inverse scattering theory for electromagnetism The first three chapters written comprehensively can be used as a textbook for undergraduate students Beginning with elementary vector calculus this book provides fundamental results for wave equations and Helmholtz equations and summarizes the potential theory It also explains the cohomology theory in an easy and straightforward way which is an essential part of electromagnetism related to geometry It then describes the scattering theory for the Maxwell equation by the time dependent method and also by the stationary method in a concise but almost self contained manner Based on these preliminary results the book proceeds to the inverse problem for the Maxwell equation The chapters for the potential theory and elementary cohomology theory are good introduction to graduate students The results in the last chapter on the inverse scattering for the medium and the determination of Betti numbers are new and will give a current scope for the inverse spectral problem on non compact manifolds It will be useful for young researchers who are interested in this field and trying to find new problems

Mathematical Analysis of Continuum Mechanics and Industrial Applications Hiromichi Itou, Masato Kimura, Vladimír Chalupecký, Kohji Ohtsuka, Daisuke Tagami, Akira Takada, 2016-11-18 This book focuses on mathematical theory and numerical simulation related to various aspects of continuum mechanics such as fracture mechanics elasticity plasticity pattern dynamics inverse problems optimal shape design material design and disaster estimation related to earthquakes Because these problems have become more important in engineering and industry further development of mathematical study of them is required for future applications Leading researchers with profound knowledge of mathematical analysis from the fields of applied mathematics physics seismology engineering and industry provide the contents of this book They help readers to understand that mathematical theory can be applied not only to different types of industry but also to a broad range of industrial problems including materials processes and products

Unveiling the Energy of Verbal Artistry: An Emotional Sojourn through **A Qualitative Approach To Inverse Scattering Theory Applied Mathematical Sciences**

In a world inundated with monitors and the cacophony of instantaneous communication, the profound power and psychological resonance of verbal art frequently fade into obscurity, eclipsed by the regular barrage of noise and distractions. Yet, nestled within the musical pages of **A Qualitative Approach To Inverse Scattering Theory Applied Mathematical Sciences**, a captivating work of literary brilliance that pulses with organic feelings, lies an memorable journey waiting to be embarked upon. Published by a virtuoso wordsmith, that mesmerizing opus courses visitors on an emotional odyssey, lightly exposing the latent potential and profound affect embedded within the delicate internet of language. Within the heart-wrenching expanse of this evocative examination, we shall embark upon an introspective exploration of the book is key subjects, dissect their charming writing fashion, and immerse ourselves in the indelible impact it leaves upon the depths of readers souls.

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