

Scattering Theory in Quantum Mechanical Problems

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Abstract. The aim of the lecture is to briefly describe the mathematical background of scattering theory for two- and three-particle quantum systems. We discuss basic objects of the theory: wave and scattering operators and the corresponding scattering matrix and illustrate them on the example of the Schrödinger equation. Our goal is to present time-dependent and stationary approaches and to describe the underlying mathematical methods. We also give a sketch of scattering theory for three interacting quantum particles including a difficult problem of the asymptotic completeness of scattering channels. Along with traditional results, we discuss new scattering channels arising for long-range pair interactions.

Keywords: wave operators, scattering matrix, scattering channels, asymptotic completeness

1 Scattering in two-particle systems

1.1 Time-dependent Schrödinger equation and wave operators

Mathematical scattering theory is concerned with the study of the behavior for large times of solutions of the time-dependent Schrödinger equation

$$i\partial u/\partial t = Hu, \quad u(0) = f \in \mathcal{H}, \quad (1)$$

for a quantum system with a self-adjoint Hamiltonian H acting in a Hilbert space \mathcal{H} . Being a part of the perturbation theory, scattering theory describes asymptotics of $u(t)$ as $t \rightarrow +\infty$ or $t \rightarrow -\infty$ in terms of solutions of problem (1) with a “free” Hamiltonian H_0 . Of course, equation (1) has a unique solution $u(t) = \exp(-iHt)f$, and the solution of the same equation with the operator H_0 and the initial data $u_0(0) = f_0$ is given by the formula $u_0(t) = \exp(-iH_0t)f_0$. From the viewpoint of scattering theory the function $u(t)$ has free asymptotics as $t \rightarrow \pm\infty$ if for an appropriate initial data $f_0^{(\pm)}$ the relation

$$\lim_{t \rightarrow \pm\infty} \|u(t) - u_0^{(\pm)}(t)\| = 0, \quad u_0^{(\pm)}(t) = \exp(-iH_0t)f_0^{(\pm)}. \quad (2)$$

Scattering Theory New Methods Problems

**Yanfei Wang, Anatoly G.
Yagola, Changchun Yang**



Scattering Theory New Methods Problems:

Inverse Acoustic and Electromagnetic Scattering Theory David Colton, Rainer Kress, 2012-10-26 The inverse scattering problem is central to many areas of science and technology such as radar and sonar medical imaging geophysical exploration and nondestructive testing This book is devoted to the mathematical and numerical analysis of the inverse scattering problem for acoustic and electromagnetic waves In this third edition new sections have been added on the linear sampling and factorization methods for solving the inverse scattering problem as well as expanded treatments of iteration methods and uniqueness theorems for the inverse obstacle problem These additions have in turn required an expanded presentation of both transmission eigenvalues and boundary integral equations in Sobolev spaces As in the previous editions emphasis has been given to simplicity over generality thus providing the reader with an accessible introduction to the field of inverse scattering theory Review of earlier editions Colton and Kress have written a scholarly state of the art account of their view of direct and inverse scattering The book is a pleasure to read as a graduate text or to dip into at leisure It suggests a number of open problems and will be a source of inspiration for many years to come SIAM Review September 1994 This book should be on the desk of any researcher any student any teacher interested in scattering theory Mathematical Intelligencer June 1994

Methods of Inverse Problems in Physics Dilip N. Ghosh Roy, 1991-03-14 This interesting volume focuses on the second of the two broad categories into which problems of physical sciences fall direct or forward and inverse or backward problems It emphasizes one dimensional problems because of their mathematical clarity The unique feature of the monograph is its rigorous presentation of inverse problems from quantum scattering to vibrational systems transmission lines and imaging sciences in a single volume It includes exhaustive discussions on spectral function inverse scattering integral equations of Gel'fand Levitan and Marcenko Povzner Levitan and Levin transforms Møller wave operators and Krein's functionals S matrix and scattering data and inverse scattering transform for solving nonlinear evolution equations via inverse solving of a linear isospectral Schrödinger equation and multisoliton solutions of the KdV equation which are of special interest to quantum physicists and mathematicians The book also gives an exhaustive account of inverse problems in discrete systems including inverting a Jacobi and a Toeplitz matrix which can be applied to geophysics electrical engineering applied mechanics and mathematics A rigorous inverse problem for a continuous transmission line developed by Brown and Wilcox is included The book concludes with inverse problems in integral geometry specifically Radon's transform and its inversion which is of particular interest to imaging scientists This fascinating volume will interest anyone involved with quantum scattering theoretical physics linear and nonlinear optics geosciences mechanical biomedical and electrical engineering and imaging research

Scattering Theory Asim Orhan Barut, 1969

Scattering Theory, 1950

Inverse Problems in Partial Differential Equations David L. Colton, Richard E. Ewing, William Rundell, Society for Industrial and Applied Mathematics, 1990-01-01

The Factorization Method for Inverse Problems Andreas Kirsch, Natalia Grinberg, 2008

The factorization method discovered by Professor Kirsch is a relatively new method for solving certain types of inverse scattering problems and problems in tomography. The text introduces the reader to this promising approach and discusses the wide applicability of this method by choosing typical examples. *Surveys on Solution Methods for Inverse Problems* David Colton, Heinz W. Engl, Alfred K. Louis, Joyce McLaughlin, William Rundell, 2012-12-06. Inverse problems are concerned with determining causes for observed or desired effects. Problems of this type appear in many application fields both in science and in engineering. The mathematical modelling of inverse problems usually leads to ill posed problems i.e. problems where solutions need not exist, need not be unique or may depend discontinuously on the data. For this reason numerical methods for solving inverse problems are especially difficult; special methods have to be developed which are known under the term regularization methods. This volume contains twelve survey papers about solution methods for inverse and ill posed problems and about their application to specific types of inverse problems e.g. in scattering theory in tomography and medical applications in geophysics and in image processing. The papers have been written by leading experts in the field and provide an up to date account of solution methods for inverse problems. **Optimization and Regularization for Computational Inverse Problems and Applications** Yanfei Wang, Anatoly G. Yagola, Changchun Yang, 2011-06-29. Optimization and Regularization for Computational Inverse Problems and Applications focuses on advances in inversion theory and recent developments with practical applications, particularly emphasizing the combination of optimization and regularization for solving inverse problems. This book covers both the methods including standard regularization theory, Fejer processes for linear and nonlinear problems, the balancing principle, extrapolated regularization, nonstandard regularization, nonlinear gradient method, the nonmonotone gradient method, subspace method and Lie group method, and the practical applications such as the reconstruction problem for inverse scattering, molecular spectra, data processing, quantitative remote sensing, inversion, seismic inversion using the Lie group method and the gravitational lensing problem. Scientists, researchers and engineers as well as graduate students engaged in applied mathematics, engineering, geophysics, medical science, image processing, remote sensing and atmospheric science will benefit from this book. Dr Yanfei Wang is a Professor at the Institute of Geology and Geophysics, Chinese Academy of Sciences, China. Dr Sc Anatoly G Yagola is a Professor and Assistant Dean of the Physical Faculty, Lomonosov Moscow State University, Russia. Dr Changchun Yang is a Professor and Vice Director of the Institute of Geology and Geophysics, Chinese Academy of Sciences, China. *Energy Research Abstracts*, 1986. *Nuclear Science Abstracts*, 1976-03. *Scattering of Light in a Turbid Medium* K. S. Shifrin, 1968. **Inverse Problems in the Mathematical Sciences** Charles W. Groetsch, 2013-12-14. Classical applied mathematics is dominated by the Laplacian paradigm of known causes evolving continuously into uniquely determined effects. The classical direct problem is then to find the unique effect of a given cause by using the appropriate law of evolution. It is therefore no surprise that traditional teaching in mathematics and the natural sciences emphasizes the point of view that problems have a solution; this solution is

unique and the solution is insensitive to small changes in the problem. Such problems are called well posed and they typically arise from the so called direct problems of natural science. The demands of science and technology have recently brought to the fore many problems that are inverse to the classical direct problems, that is problems which may be interpreted as finding the cause of a given effect or finding the law of evolution given the cause and effect. Included among such problems are many questions of remote sensing or indirect measurement such as the determination of internal characteristics of an inaccessible region from measurements on its boundary, the determination of system parameters from input output measurements and the reconstruction of past events from measurements of the present state. Inverse problems of this type are often ill posed in the sense that distinct causes can account for the same effect and small changes in a perceived effect can correspond to very large changes in a given cause. Very frequently such inverse problems are modeled by integral equations of the first kind.

Catalog of Copyright Entries. Third Series Library of Congress. Copyright Office, 1972 *Atoms and Molecules in Strong External Fields* P. Schmelcher, W. Schweizer, 2007-05-08. This book contains contributions to the 172 WE Heraeus Seminar Atoms and Molecules in Strong External Fields which took place April 7-11 1997 at the Phys. Zentrum Bad Honnef, Germany. The designation strong fields applies to external static magnetic and/or electric fields that are sufficiently intense to cause alterations in the atomic or molecular structure and dynamics. The specific topics treated are the behavior and properties of atoms in strong static fields, the fundamental aspects and electronic structure of molecules in strong magnetic fields, the dynamics and aspects of chaos in highly excited Rydberg atoms in external fields, matter in the atmosphere of astrophysical objects, white dwarfs, neutron stars and quantum nanostructures in strong magnetic fields. It is obvious that the elaboration of the corresponding properties in these regimes causes the greatest difficulties and is incomplete even today. Present day technology has made it possible for many research groups to study the behavior of matter in strong external fields, both experimentally and theoretically, where the phrase experimentally includes the astronomical observations. Understanding these systems requires the development of modern theories and powerful computational techniques. Interdisciplinary collaborations will be helpful and useful in developing more efficient methods to understand these important systems. Hence the idea was to bring together people from different fields like atomic and molecular physics, theoretical chemistry, astrophysics and all those colleagues interested in aspects of few body systems in external fields. **Quantum Effects in Information Transmission**

Systems I. A. Deryugin, V. N. Kurashov, 1967 *Large-Scale Optimization with Applications* Lorenz T. Biegler, 1997-07-31. With contributions by specialists and practitioners in the fields of aerospace engineering, chemical engineering and fluid and solid mechanics, the major themes include an assessment of the state of the art in optimization algorithms as well as challenging applications in design and control in the areas of process engineering and systems with partial differential equation models. *Applied Mechanics Reviews*, 1989 **Dynamics of Molecules and Chemical**

Reactions Robert Wyatt, 1996-06-27. Covers both molecular and reaction dynamics. The work presents important theoretical

and computational approaches to the study of energy transfer within and between molecules discussing the application of these approaches to problems of experimental interest It also describes time dependent and time independent methods variational and perturbative techniques iterative and direct approaches and methods based upon the use of physical grids of finite sets of basic function 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 *Air Force Research Resumés* ,

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