The Mathematics of the Bose Gas and its Condensation

Elliott H. Lieb
Robert Seiringer
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    The Mathematics of the Bose Gas and its Condensation Elliott H. Lieb,Robert Seiringer,Jan Philip Solovej,Jakob Yngvason,2006-01-17 This book contains a unique survey of the mathematically rigorous results about the quantum mechanical many body problem that have been obtained by the authors in the past seven years It addresses a topic that is not only rich mathematically using a large variety of techniques in mathematical analysis but is also one with strong ties to current experiments on ultra cold Bose gases and Bose Einstein condensation The book provides a pedagogical entry into an active area of ongoing research for both graduate students and researchers It is an outgrowth of a course given by the authors for graduate students and post doctoral researchers at the Oberwolfach Research Institute in 2004 The book also provides a coherent summary of the field and a reference for mathematicians and physicists active in research on quantum mechanics   *An Introduction to Lieb's Simplified Approach to the Bose Gas* Ian Jauslin,2025-01-30 This book explores Lieb s Simplified approach to the ground state of systems of interacting bosons While extensive research has delved into the behavior of interacting bosons persistent challenges such as proving Bose Einstein condensation remain Introduced by Lieb in 1963 the Simplified approach has been the object of renewed attention in recent years revealing surprising and promising results Notably this approach provides ground state energy predictions that agree with many body systems asymptotically at both low and high densities It further predicts a condensate fraction and correlation function that agree with Bogolyubov theory at low densities and numerical predictions match quantum Monte Carlo simulations across all densities This suggests that Lieb s Simplified approach could serve as a potent tool for reimagining the study of interacting bosons The book defines Lieb s Simplified approach discusses its predictions and presents known analytical and numerical results It is designed for advanced students and young researchers working in the fields of mathematical physics quantum many body physics and Bose Einstein condensates   *Physics and Mathematics of Quantum Many-Body Systems* Hal Tasaki,2020-05-07 This book is a self contained advanced textbook on the mathematical physical aspects of quantum many body systems which begins with a pedagogical presentation of the necessary background information before moving on to subjects of active research including topological phases of matter The book explores in detail selected topics in quantum spin systems and lattice electron systems namely long range order and spontaneous symmetry breaking in the antiferromagnetic Heisenberg model in two or higher dimensions Part I Haldane phenomena in antiferromagnetic quantum spin chains and related topics in topological phases of quantum matter Part II and the origin of magnetism in various versions of the Hubbard model Part III Each of these topics represents certain nontrivial phenomena or features that are invariably encountered in a variety of quantum many body systems including quantum field theory condensed matter systems cold atoms and artificial quantum systems designed for future quantum computers The book s main focus is on universal properties of quantum many body systems The book includes roughly 50 problems with detailed solutions The reader only requires elementary linear algebra and calculus to

comprehend the material and work through the problems Given its scope and format the book is suitable both for self study and as a textbook for graduate or advanced undergraduate classes *Macroscopic Limits of Quantum Systems* Daniela Cadamuro,Maximilian Duell,Wojciech Dybalski,Sergio Simonella,2018-10-26 Based on the workshop of the same name this proceedings volume presents selected research investigating the mathematics of collective phenomena emerging from quantum theory at observable scales Featured contributions from leading scientists provide a thorough overview of current and active research Methods from functional analysis spectral theory renormalization group theory and variational calculus are used to prove rigorous results in quantum physics Topics include superconductivity and mathematical aspects of the BCS theory the Jellium model and Bose Einstein condensation among others Presenting technical details in an accessible way this book serves as an introduction to research for advanced graduate students and is suitable for specialists in mathematical physics The workshop Macroscopic Limits of Quantum Systems was held over three days in the spring of 2017 at the Technical University of Munich The conference celebrated the achievementsof Herbert Spohn and his reception of the Max Planck Medal   Mathematical Results in Quantum Mechanics Ingrid Beltita,2008 The 10th Quantum Mathematics International Conference Qmath10 gave an opportunity to bring together specialists interested in that part of mathematical physics which is in close connection with various aspects of quantum theory It was also meant to introduce young scientists and new tendencies in the field This collection of carefully selected papers aims to reflect recent techniques and results on Schr dinger operators with magnetic fields random Schr dinger operators condensed matter and open systems pseudo differential operators and semiclassical analysis quantum field theory and relativistic quantum mechanics quantum information and much more The book serves as a concise and well documented tool for the more experimented scientists as well as a research guide for postgraduate students   **Mathematical Results In Quantum Mechanics - Proceedings Of The Qmath10 Conference** Radu Purice,Ingrid Beltita,Gheorghe Nenciu,2008-08-11 The 10th Quantum Mathematics International Conference Qmath10 gave an opportunity to bring together specialists interested in that part of mathematical physics which is in close connection with various aspects of quantum theory It was also meant to introduce young scientists and new tendencies in the field This collection of carefully selected papers aims to reflect recent techniques and results on Schr dinger operators with magnetic fields random Schr dinger operators condensed matter and open systems pseudo differential operators and semiclassical analysis quantum field theory and relativistic quantum mechanics quantum information and much more The book serves as a concise and well documented tool for the more experimented scientists as well as a research guide for postgraduate students   *Quantum Mathematics II* Michele Correggi,Marco Falconi,2023-12-08 This book is the second volume that provides an unique overview of the most recent and relevant contributions in the field of mathematical physics with a focus on the mathematical features of quantum mechanics It is a collection of review papers together with brand new works related to the activities of the INdAM Intensive Period INdAM Quantum Meetings IQM22

which took place at the Politecnico di Milano in Spring 2022 at Politecnico di Milano The range of topics covered by the book is wide going ranging from many body quantum mechanics to quantum field theory and open quantum systems **Fifth International Congress of Chinese Mathematicians** Lizhen Ji,2012 This two part volume represents the proceedings of the Fifth International Congress of Chinese Mathematicians held at Tsinghua University Beijing in December 2010 The Congress brought together eminent Chinese and overseas mathematicians to discuss the latest developments in pure and applied mathematics Included are 60 papers based on lectures given at the conference <u>Recent Advances in Differential Equations and Mathematical Physics</u> Nikolai Chernov,2006 Surveys topics in differential equations that are associated with mathematical physics This book includes such topics as asymptotic formulas for the ground state energy of fermionic gas J self adjoint Dirac operators and spectral theory of Schrodinger operators It is suitable for mathematicians and physicists

Analysis and Stochastics of Growth Processes and Interface Models Peter Mörters,Roger Moser,Mathew Penrose,Hartmut Schwetlick,Johannes Zimmer,2008-07-24 This book is a collection of topical survey articles by leading researchers in the fields of applied analysis and probability theory working on the mathematical description of growth phenomena Particular emphasis is on the interplay of the two fields with articles by analysts being accessible for researchers in probability and vice versa Mathematical methods discussed in the book comprise large deviation theory lace expansion harmonic multi scale techniques and homogenisation of partial differential equations Models based on the physics of individual particles are discussed alongside models based on the continuum description of large collections of particles and the mathematical theories are used to describe physical phenomena such as droplet formation Bose Einstein condensation Anderson localization Ostwald ripening or the formation of the early universe The combination of articles from the two fields of analysis and probability is highly unusual and makes this book an important resource for researchers working in all areas close to the interface of these fields **Many-Body Schrödinger Dynamics of Bose-Einstein Condensates** Kaspar Sakmann,2011-08-31 At extremely low temperatures clouds of bosonic atoms form what is known as a Bose Einstein condensate Recently it has become clear that many different types of condensates so called fragmented condensates exist In order to tell whether fragmentation occurs or not it is necessary to solve the full many body Schr dinger equation a task that remained elusive for experimentally relevant conditions for many years In this thesis the first numerically exact solutions of the time dependent many body Schr dinger equation for a bosonic Josephson junction are provided and compared to the approximate Gross Pitaevskii and Bose Hubbard theories It is thereby shown that the dynamics of Bose Einstein condensates is far more intricate than one would anticipate based on these approximations A special conceptual innovation in this thesis are optimal lattice models It is shown how all quantum lattice models of condensed matter physics that are based on Wannier functions e g the Bose Fermi Hubbard model can be optimized variationally This leads to exciting new physics **Emergent Nonlinear Phenomena in Bose-Einstein Condensates** Panayotis G. Kevrekidis,Dimitri J. Frantzeskakis,Ricardo

Carretero-González,2007-12-29 This book written by experts in the fields of atomic physics and nonlinear science covers the important developments in a special aspect of Bose Einstein condensation namely nonlinear phenomena in condensates Topics covered include bright dark gap and multidimensional solitons vortices vortex lattices optical lattices multicomponent condensates mathematical methods rigorous results and the beyond the mean field approach   *Condensed Matter Physics and Exactly Soluble Models* Elliott H. Lieb,2013-06-29 This is the third Selecta of publications of Elliott Lieb the first two being Stabil ity of Matter From Atoms to Stars edited by Walter Thirring and Inequalities edited by Michael Loss and Mary Beth Ruskai A companion fourth Selecta on Statistical Mechanics is also edited by us Elliott Lieb has been a pioneer of the discipline of mathematical physics as it is nowadays understood and continues to lead several of its most active directions today For the first part of this selecta we have made a selection of Lieb s works on Condensed Matter Physics The impact of Lieb s work in mathematical con densed matter physics is unrivaled It is fair to say that if one were to name a founding father of the field Elliott Lieb would be the only candidate to claim this singular position While in related fields such as Statistical Mechanics and Atomic Physics many key problems are readily formulated in unambiguous mathematical form this is less so in Condensed Matter Physics where some say that rigor is probably impossible and certainly unnecessary By carefully select ing the most important questions and formulating them as well defined mathemat ical problems and then solving a good number of them Lieb has demonstrated the quoted opinion to be erroneous on both counts What is true however is that many of these problems turn out to be very hard It is not unusual that they take a decade even several decades to solve

Mathematical Concepts of Quantum Mechanics Stephen J. Gustafson,Israel Michael Sigal,2020-10-21 The book gives a streamlined introduction to quantum mechanics while describing the basic mathematical structures underpinning this discipline Starting with an overview of key physical experiments illustrating the origin of the physical foundations the book proceeds with a description of the basic notions of quantum mechanics and their mathematical content It then makes its way to topics of current interest specifically those in which mathematics plays an important role The more advanced topics presented include many body systems modern perturbation theory path integrals the theory of resonances adiabatic theory geometrical phases Aharonov Bohm effect density functional theory open systems the theory of radiation non relativistic quantum electrodynamics and the renormalization group With different selections of chapters the book can serve as a text for an introductory intermediate or advanced course in quantum mechanics Some of the sections could be used for introductions to geometrical methods in Quantum Mechanics to quantum information theory and to quantum electrodynamics and quantum field theory   *Correlations in Low-Dimensional Quantum Gases* Guillaume Lang,2018-12-29 The book addresses several aspects of thermodynamics and correlations in the strongly interacting regime of one dimensional bosons a topic at the forefront of current theoretical and experimental studies Strongly correlated systems of one dimensional bosons have a long history of theoretical study Their experimental realisation in ultracold atom experiments is the subject of current research

which took off in the early 2000s Yet these experiments raise new theoretical questions just begging to be answered Correlation functions are readily available for experimental measurements In this book they are tackled by means of sophisticated theoretical methods developed in condensed matter physics and mathematical physics such as bosonization the Bethe Ansatz and conformal field theory Readers are introduced to these techniques which are subsequently used to investigate many body static and dynamical correlation functions **Localization in Periodic Potentials** Dmitry E. Pelinovsky,2011-10-06 This book provides a comprehensive treatment of the Gross Pitaevskii equation with a periodic potential in particular the localized modes supported by the periodic potential It takes the mean field model of the Bose Einstein condensation as the starting point of analysis and addresses the existence and stability of localized modes The mean field model is simplified further to the coupled nonlinear Schr dinger equations the nonlinear Dirac equations and the discrete nonlinear Schr dinger equations One of the important features of such systems is the existence of band gaps in the wave transmission spectra which support stationary localized modes known as the gap solitons These localized modes realise a balance between periodicity dispersion and nonlinearity of the physical system Written for researchers in applied mathematics this book mainly focuses on the mathematical properties of the Gross Pitaevskii equation It also serves as a reference for theoretical physicists interested in localization in periodic potentials *Seminar on Stochastic Analysis, Random Fields and Applications VII* Robert C. Dalang,Marco Dozzi,Francesco Russo,2013-09-05 This volume contains refereed research or review articles presented at the 7th Seminar on Stochastic Analysis Random Fields and Applications which took place at the Centro Stefano Franscini Monte Verit in Ascona Switzerland in May 2011 The seminar focused mainly on stochastic partial differential equations especially with jump processes construction of solutions and approximations Malliavin calculus and Stein methods and other techniques in stochastic analysis especially chaos representations and convergence and applications to models of interacting particle systems stochastic methods in financial models especially models for power markets or for risk analysis empirical estimation and approximation stochastic control and optimal pricing The book will be a valuable resource for researchers in stochastic analysis and for professionals interested in stochastic methods in finance **Advances in Quantum Mechanics** Alessandro Michelangeli,Gianfausto Dell'Antonio,2017-08-01 This volume collects recent contributions on the contemporary trends in the mathematics of quantum mechanics and more specifically in mathematical problems arising in quantum many body dynamics quantum graph theory cold atoms unitary gases with particular emphasis on the developments of the specific mathematical tools needed including linear and non linear Schr dinger equations topological invariants non commutative geometry resonances and operator extension theory among others Most of contributors are international leading experts or respected young researchers in mathematical physics PDE and operator theory All their material is the fruit of recent studies that have already become a reference in the community Offering a unified perspective of the mathematics of quantum mechanics it is a

valuable resource for researchers in the field **Hyperspherical Harmonics And Their Physical Applications** James Emil Avery,John Scales Avery,2017-11-27 Hyperspherical harmonics are extremely useful in nuclear physics and reactive scattering theory However their use has been confined to specialists with very strong backgrounds in mathematics This book aims to change the theory of hyperspherical harmonics from an esoteric field mastered by specialists into an easily used tool with a place in the working kit of all theoretical physicists theoretical chemists and mathematicians The theory presented here is accessible without the knowledge of Lie groups and representation theory and can be understood with an ordinary knowledge of calculus The book is accompanied by programs and exercises designed for teaching and practical use

Perspectives in Analysis Michael Benedicks,Peter Jones,Stanislav Smirnov,2006-06-01 The Conference Perspectives in Analysis was held during May 26 28 2003 at the Royal Institute of Technology in Stockholm Sweden The purpose of the conference was to consider the future of analysis along with its relations to other areas of mathematics and physics and to celebrate the seventy fth birthday of Lennart Carleson The scienti c theme was one with which the name of Lennart Carleson has been associated for over fty years His modus operandi has long been to carry out a twofold approach to the selection of research problems First one should look for promising new areas of ana sis especially those having close contact with physically oriented problems of geometric character The second step is to select a core set of problems that require new techniques for their resolutions After making a central contri tion Lennart would usually move on to a new area though he might return to the topic of his previous work if new techniques were developed that could break old mathematical log jams Lennart s operating approach is based on fundamental realities of modern mathematics as well as his own inner c victions Here we rst refer to an empirical fact of mathematical research All topics have a nite half life with fteen years being an upper bound for most areas After that time it is usually a good idea to move on to so thing new

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