

# **Many-Body Quantum Theory in Condensed Matter Physics**

*An Introduction*

Henrik Bruus  
Karsten Flensberg

OXFORD GRADUATE TEXTS

# Many Body Quantum Theory In Condensed Matter Physics An Introduction

**Piers Coleman**



## **Many Body Quantum Theory In Condensed Matter Physics An Introduction:**

**Many-Body Quantum Theory in Condensed Matter Physics** Henrik Bruus, Karsten Flensberg, 2004-09-03 This book is an introduction to the techniques of many body quantum theory with a large number of applications to condensed matter physics The basic idea of the book is to provide a self contained formulation of the theoretical framework without losing mathematical rigor while at the same time providing physical motivation and examples The examples are taken from applications in electron systems and transport theory On the formal side the book covers an introduction to second quantization many body Green s function finite temperature Feynman diagrams and bosonization The applications include traditional transport theory in bulk as well as mesoscopic systems where both the Landau B ttiker formalism and recent developments in correlated transport phenomena in mesoscopic systems and nano structures are covered Other topics include interacting electron gases plasmons electron phonon interactions superconductivity and a final chapter on one dimensional systems where a detailed treatment of Luttinger liquid theory and bosonization techniques is given Having grown out of a set of lecture notes and containing many pedagogical exercises this book is designed as a textbook for an advanced undergraduate or graduate course and is also well suited for self study     [Quantum Theory of Many-Body Systems](#) Alexandre Zagoskin, 2014-06-26 This text presents a self contained treatment of the physics of many body systems from the point of view of condensed matter The approach quite traditionally uses the mathematical formalism of quasiparticles and Green s functions In particular it covers all the important diagram techniques for normal and superconducting systems including the zero temperature perturbation theory and the Matsubara Keldysh and Nambu Gor kov formalism as well as an introduction to Feynman path integrals This new edition contains an introduction to the methods of theory of one dimensional systems bosonization and conformal field theory and their applications to many body problems Intended for graduate students in physics and related fields the aim is not to be exhaustive but to present enough detail to enable the student to follow the current research literature or to apply the techniques to new problems Many of the examples are drawn from mesoscopic physics which deals with systems small enough that quantum coherence is maintained throughout their volume and which therefore provides an ideal testing ground for many body theories     **Many-Body Theory of Condensed Matter Systems** Michael G. Cottam, Zahra Haghshenasfard, 2020-07-30 For non specialist students and researchers this is a broad and concise introduction to the many body theory of condensed matter systems     *Introduction to Many-Body Physics* Piers Coleman, 2015-11-26 This book explains the tools and concepts needed for a research level understanding of the subject for graduate students in condensed matter physics     **Condensed Matter Field Theory** Alexander Altland, Ben D. Simons, 2010-03-11 Modern experimental developments in condensed matter and ultracold atom physics present formidable challenges to theorists This book provides a pedagogical introduction to quantum field theory in many particle physics emphasizing the applicability of the formalism to concrete problems This second edition contains two new chapters

developing path integral approaches to classical and quantum nonequilibrium phenomena Other chapters cover a range of topics from the introduction of many body techniques and functional integration to renormalization group methods the theory of response functions and topology Conceptual aspects and formal methodology are emphasized but the discussion focuses on practical experimental applications drawn largely from condensed matter physics and neighboring fields Extended and challenging problems with fully worked solutions provide a bridge between formal manipulations and research oriented thinking Aimed at elevating graduate students to a level where they can engage in independent research this book

complements graduate level courses on many particle theory *Many-Body Techniques in Condensed Matter Physics* Jaime Merino, Alfredo Levy Yeyati, 2024-06-05 This book presents the lecture notes and exercises corresponding to the course Quantum Field Theoretical Methods in Condensed Matter that the authors imparted for several years as part of the masters program on Condensed Matter and Biological Systems at the Autonoma University of Madrid It provides a step by step description of the material which will benefit not only professors wishing to undertake a similar task but also interested students Additionally the book provides a complete set of exercises on the various topics along with hints about how to solve them a feature frequently absent in textbooks on many body techniques As well as addressing the traditional topics in the field diagrammatic techniques screening in metals Fermi liquid theory electron phonon interactions etc the text also covers less conventional topics such as the application of non equilibrium Green function techniques to quantum transport in normal and superconducting nanoscale devices **Quantum Field Theory of Many-Body Systems** Xiao-Gang Wen, 2004-06-04

For most of the last century condensed matter physics has been dominated by band theory and Landau's symmetry breaking theory In the last twenty years however there has been the emergence of a new paradigm associated with fractionalisation topological order emergent gauge bosons and fermions and string condensation These new physical concepts are so fundamental that they may even influence our understanding of the origin of light and fermions in the universe This book is a pedagogical and systematic introduction to the new concepts and quantum field theoretical methods which have fuelled the rapid developments in condensed matter physics It discusses many basic notions in theoretical physics which underlie physical phenomena in nature Topics covered are dissipative quantum systems boson condensation symmetry breaking and gapless excitations phase transitions Fermi liquids spin density wave states Fermi and fractional statistics quantum Hall effects topological and quantum order spin liquids and string condensation Methods covered are the path integral Green's functions mean field theory effective theory renormalization group bosonization in one and higher dimensions non linear sigma model quantum gauge theory dualities slave boson theory and exactly soluble models beyond one dimension This book is aimed at teaching graduate students and bringing them to the frontiers of research in condensed matter physics

Quantum Mechanics with Applications to Nanotechnology and Information Science Yehuda B. Band, Yshai Avishai, 2013-01-10 Quantum mechanics transcends and supplants classical mechanics at the atomic and subatomic levels It

provides the underlying framework for many subfields of physics chemistry and materials science including condensed matter physics atomic physics molecular physics quantum chemistry particle physics and nuclear physics It is the only way we can understand the structure of materials from the semiconductors in our computers to the metal in our automobiles It is also the scaffolding supporting much of nanoscience and nanotechnology The purpose of this book is to present the fundamentals of quantum theory within a modern perspective with emphasis on applications to nanoscience and nanotechnology and information technology As the frontiers of science have advanced the sort of curriculum adequate for students in the sciences and engineering twenty years ago is no longer satisfactory today Hence the emphasis on new topics that are not included in older reference texts such as quantum information theory decoherence and dissipation and on applications to nanotechnology including quantum dots wires and wells This book provides a novel approach to Quantum Mechanics whilst also giving readers the requisite background and training for the scientists and engineers of the 21st Century who need to come to grips with quantum phenomena The fundamentals of quantum theory are provided within a modern perspective with emphasis on applications to nanoscience and nanotechnology and information technology Older books on quantum mechanics do not contain the amalgam of ideas concepts and tools necessary to prepare engineers and scientists to deal with the new facets of quantum mechanics and their application to quantum information science and nanotechnology As the frontiers of science have advanced the sort of curriculum adequate for students in the sciences and engineering twenty years ago is no longer satisfactory today There are many excellent quantum mechanics books available but none have the emphasis on nanotechnology and quantum information science that this book has

**Nonequilibrium Many-Body Theory of Quantum Systems** Gianluca Stefanucci, Robert van Leeuwen, 2013-03-07 The Green's function method is one of the most powerful and versatile formalisms in physics and its nonequilibrium version has proved invaluable in many research fields This book provides a unique self contained introduction to nonequilibrium many body theory Starting with basic quantum mechanics the authors introduce the equilibrium and nonequilibrium Green's function formalisms within a unified framework called the contour formalism The physical content of the contour Green's functions and the diagrammatic expansions are explained with a focus on the time dependent aspect Every result is derived step by step critically discussed and then applied to different physical systems ranging from molecules and nanostructures to metals and insulators With an abundance of illustrative examples this accessible book is ideal for graduate students and researchers who are interested in excited state properties of matter and nonequilibrium physics

**Solid State Theory** Ulrich Rössler, 2009-08-29 Solid State Theory An Introduction is a textbook for graduate students of physics and material sciences Whilst covering the traditional topics of older textbooks it also takes up new developments in theoretical concepts and materials that are connected with such breakthroughs as the quantum Hall effects the high T<sub>c</sub> superconductors and the low dimensional systems realized in solids Thus besides providing the fundamental concepts to describe the physics of the electrons and ions comprising the solid

including their interactions the book casts a bridge to the experimental facts and gives the reader an excellent insight into current research fields A compilation of problems makes the book especially valuable to both students and teachers

*Quantum Foundations And Open Quantum Systems: Lecture Notes Of The Advanced School* Theo M

Nieuwenhuizen, Claudia Pombo, Claudio Furtado, Andrei Yu Khrennikov, Inacio A Pedrosa, Vaclav Spicka, 2014-10-03 The Advanced School on Quantum Foundations and Open Quantum Systems was an exceptional combination of lectures These comprise lectures in standard physics and investigations on the foundations of quantum physics On the one hand it included lectures on quantum information quantum open systems quantum transport and quantum solid state On the other hand it included lectures on quantum measurement models for elementary particles sub quantum structures and aspects on the philosophy and principles of quantum physics The special program of this school offered a broad outlook on the current and near future fundamental research in theoretical physics The lectures are at the level of PhD students *Quantum*

*Many-Body Physics in a Nutshell* Edward Shuryak, 2018-11-27 The ideal textbook for a one semester introductory course for graduate students or advanced undergraduates This book provides an essential introduction to the physics of quantum many body systems which are at the heart of atomic and nuclear physics condensed matter and particle physics Unlike other textbooks on the subject it covers topics across a broad range of physical fields phenomena as well as theoretical tools and does so in a simple and accessible way Edward Shuryak begins with Feynman diagrams of the quantum and statistical mechanics of a particle in these applications the diagrams are easy to calculate and there are no divergencies He discusses the renormalization group and illustrates its uses and covers systems such as weakly and strongly coupled Bose and Fermi gases electron gas nuclear matter and quark gluon plasmas Phenomena include Bose condensation and superfluidity Shuryak also looks at Cooper pairing and superconductivity for electrons in metals liquid  $^3\text{He}$  nuclear matter and quark gluon plasma A recurring topic throughout is topological matter ranging from ensembles of quantized vortices in superfluids and superconductors to ensembles of colored QCD monopoles and instantons in the QCD vacuum Proven in the classroom

*Quantum Many Body Physics in a Nutshell* is the ideal textbook for a one semester introductory course for graduate students or advanced undergraduates Teaches students how quantum many body systems work across many fields of physics Uses path integrals from the very beginning Features the easiest introduction to Feynman diagrams available Draws on the most recent findings including trapped Fermi and Bose atomic gases Guides students from traditional systems such as electron gas and nuclear matter to more advanced ones such as quark gluon plasma and the QCD vacuum *The Non-Equilibrium*

*Green's Function Method for Nanoscale Device Simulation* Mahdi Pourfath, 2014-07-05 For modeling the transport of carriers in nanoscale devices a Green function formalism is the most accurate approach Due to the complexity of the formalism one should have a deep understanding of the underlying principles and use smart approximations and numerical methods for solving the kinetic equations at a reasonable computational time In this book the required concepts from quantum and

statistical mechanics and numerical methods for calculating Green functions are presented The Green function is studied in detail for systems both under equilibrium and under nonequilibrium conditions Because the formalism enables rigorous modeling of different scattering mechanisms in terms of self energies but an exact evaluation of self energies for realistic systems is not possible their approximation and inclusion in the quantum kinetic equations of the Green functions are elaborated All the elements of the kinetic equations which are the device Hamiltonian contact self energies and scattering self energies are examined and efficient methods for their evaluation are explained Finally the application of these methods to study novel electronic devices such as nanotubes graphene Si nanowires and low dimensional thermoelectric devices and photodetectors are discussed *Lecture Notes On Field Theory In Condensed Matter Physics* Christopher

Mudry,2014-02-28 The aim of this book is to introduce a graduate student to selected concepts in condensed matter physics for which the language of field theory is ideally suited The examples considered in this book are those of superfluidity for weakly interacting bosons collinear magnetism and superconductivity Quantum phase transitions are also treated in the context of quantum dissipative junctions and interacting fermions constrained to one dimensional position space The style of presentation is sufficiently detailed and comprehensive that it only presumes familiarity with undergraduate physics

*Quantum Theory* Peter Bongaarts,2014-12-01 This book was inspired by the general observation that the great theories of modern physics are based on simple and transparent underlying mathematical structures a fact not usually emphasized in standard physics textbooks which makes it easy for mathematicians to understand their basic features It is a textbook on quantum theory intended for advanced undergraduate or graduate students mathematics students interested in modern physics and physics students who are interested in the mathematical background of physics and are dissatisfied with the level of rigor in standard physics courses More generally it offers a valuable resource for all mathematicians interested in modern physics and all physicists looking for a higher degree of mathematical precision with regard to the basic concepts in their field **Control of Magnetotransport in Quantum Billiards** Christian V. Morfonios,Peter Schmelcher,2016-11-16

In this book the coherent quantum transport of electrons through two dimensional mesoscopic structures is explored in dependence of the interplay between the confining geometry and the impact of applied magnetic fields aiming at conductance controllability After a top down insightful presentation of the elements of mesoscopic devices and transport theory a computational technique which treats multiterminal structures of arbitrary geometry and topology is developed The method relies on the modular assembly of the electronic propagators of subsystems which are inter or intra connected providing large flexibility in system setups combined with high computational efficiency Conductance control is first demonstrated for elongated quantum billiards and arrays thereof where a weak magnetic field tunes the current by phase modulation of interfering lead coupled states geometrically separated from confined states Soft wall potentials are then employed for efficient and robust conductance switching by isolating energy persistent collimated or magnetically deflected

electron paths from Fano resonances In a multiterminal configuration the guiding and focusing property of curved boundary sections enables magnetically controlled directional transport with input electron waves flowing exclusively to selected outputs Together with a comprehensive analysis of characteristic transport features and spatial distributions of scattering states the results demonstrate the geometrically assisted design of magnetoconductance control elements in the linear response regime

*Introducing Molecular Electronics* Gianaurelio Cuniberti, Giorgos Fagas, Klaus Richter, 2006-05-21 Klaus von Klitzing Max Planck Institut für Festkörperforschung Heisenbergstraße 1 70569 Stuttgart Germany Already many Cassandras have prematurely announced the end of the silicon roadmap and yet conventional semiconductor based transistors have been continuously shrinking at a pace which has brought us to nowadays cheap and powerful microelectronics However it is clear that the traditional scaling laws cannot be applied if unwanted tunnel phenomena or ballistic transport dominate the device properties It is generally expected that a combination of silicon CMOS devices with molecular structure will dominate the field of nanoelectronics in 20 years The visionary ideas of atomic or molecular scale electronics already date back thirty years but only recently advanced nanotechnology including e.g. scanning tunneling methods and mechanically controllable break junctions have enabled to make distinct progress in this direction On the level of fundamental research state-of-the-art techniques allow to manipulate image and probe charge transport through unitary molecular systems in an increasingly controlled way Hence molecular electronics is reaching a stage of trustworthy and reproducible experiments This has led to a variety of physical and chemical phenomena recently observed for charge currents flowing through molecular junctions posing new challenges to theory As a result a still increasing number of open questions determines the future agenda in this field

**Many-Body Problems and Quantum Field Theory** Philippe Andre Martin, Francois Rothen, 2004-08-30 Many Body Problems and Quantum Field Theory introduces the concepts and methods of the topics on a level suitable for graduate students and researchers The formalism is developed in close conjunction with the description of a number of physical systems cohesion and dielectric properties of the electron gas superconductivity superfluidity nuclear matter and nucleon pairing matter and radiation interaction of fields by particle exchange and mass generation Emphasis is placed on analogies between the various systems rather than on advanced or specialized aspects with the purpose of illustrating common ideas within different domains of physics Starting from a basic knowledge of quantum mechanics and classical electromagnetism the exposition is self contained and explicitly details all steps of the derivations The new edition features a substantially new treatment of nucleon pairing

**Plasmonics and Light-Matter Interactions in Two-Dimensional Materials and in Metal Nanostructures** Paulo André Dias Gonçalves, 2020-03-19 This thesis presents a comprehensive theoretical description of classical and quantum aspects of plasmonics in three and two dimensions and also in transdimensional systems containing elements with different dimensionalities It focuses on the theoretical understanding of the salient features of plasmons in nanosystems as well as on the multifaceted aspects of plasmon enhanced light-matter



interactions at the nanometer scale Special emphasis is given to the modeling of nonclassical behavior across the transition regime bridging the classical and the quantum domains The research presented in this dissertation provides useful tools for understanding surface plasmons in various two and three dimensional nanostructures as well as quantum mechanical effects in their response and their joint impact on light matter interactions at the extreme nanoscale These contributions constitute novel and solid advancements in the research field of plasmonics and nanophotonics that will help guide future experimental investigations in the blossoming field of nanophotonics and also facilitate the design of the next generation of truly nanoscale nanophotonic devices

**Density Functional Calculations** Gang Yang, 2018-05-16 Density functional theory DFT ranks as the most widely used quantum mechanical method and plays an increasingly larger role in a number of disciplines such as chemistry physics material biology and pharmacy DFT has long been used to complement experimental investigations while now it is also regarded as an indispensable and powerful tool for researchers of different fields This book is divided into five sections that include original chapters written by experts in their fields Method Development and Validation Spectra and Thermodynamics Catalysis and Mechanism Material and Molecular Design and Multidisciplinary Integration I would like to express my sincere gratitude to all contributors and recommend this book to both beginners and experienced researchers

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