

Quantum Transport



Introduction to Nanoscience

Yuli V. Nazarov
and **Yaroslav M. Blanter**

CAMBRIDGE

Quantum Transport Introduction To Nanoscience

David Sánchez, Michael Moskalets



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Quantum Transport Yuli V. Nazarov, Yaroslav M. Blanter, 2009-05-28 Quantum transport is a diverse field sometimes combining seemingly contradicting concepts quantum and classical conduction and insulating within a single nanodevice Quantum transport is an essential and challenging part of nanoscience and understanding its concepts and methods is vital to the successful fabrication of devices at the nanoscale This textbook is a comprehensive introduction to the rapidly developing field of quantum transport The authors present the comprehensive theoretical background and explore the groundbreaking experiments that laid the foundations of the field Ideal for graduate students each section contains control questions and exercises to check readers understanding of the topics covered Its broad scope and in depth analysis of selected topics will appeal to researchers and professionals working in nanoscience **Quantum Transport** Juli V.

Nazarov, Yaroslav M. Blanter, 2009 *Quantum Transport in Mesoscopic Systems* David Sánchez, Michael Moskalets, 2021-01-06 Mesoscopic physics deals with systems larger than single atoms but small enough to retain their quantum properties The possibility to create and manipulate conductors of the nanometer scale has given birth to a set of phenomena that have revolutionized physics quantum Hall effects persistent currents weak localization Coulomb blockade etc This Special Issue tackles the latest developments in the field Contributors discuss time dependent transport quantum pumping nanoscale heat engines and motors molecular junctions electron electron correlations in confined systems quantum thermo electrics and current fluctuations The works included herein represent an up to date account of exciting research with a broad impact in both fundamental and applied topics **21st Century Nanoscience** Klaus D. Sattler, 2022-01-18 This 21st Century Nanoscience Handbook will be the most comprehensive up to date large reference work for the field of nanoscience Handbook of Nanophysics by the same editor published in the fall of 2010 was embraced as the first comprehensive reference to consider both fundamental and applied aspects of nanophysics This follow up project has been conceived as a necessary expansion and full update that considers the significant advances made in the field since 2010 It goes well beyond the physics as warranted by recent developments in the field Key Features Provides the most comprehensive up to date large reference work for the field Chapters written by international experts in the field Emphasises presentation and real results and applications This handbook distinguishes itself from other works by its breadth of coverage readability and timely topics The intended readership is very broad from students and instructors to engineers physicists chemists biologists biomedical researchers industry professionals governmental scientists and others whose work is impacted by nanotechnology It will be an indispensable resource in academic government and industry libraries worldwide The fields impacted by nanoscience extend from materials science and engineering to biotechnology biomedical engineering medicine electrical engineering pharmaceutical science computer technology aerospace engineering mechanical engineering food science and beyond *An Introduction to Condensed Matter Physics for the Nanosciences* Arthur McGurn, 2023-04-13

The book provides an accessible introduction to the principles of condensed matter physics with a focus on the nanosciences and device technologies. The basics of electronic, phononic, photonic, superconducting, optics, quantum optics, and magnetic properties are explored, and nanoscience and device materials are incorporated throughout the chapters. Many examples of the fundamental principles of condensed matter physics are taken directly from nanoscience and device applications. This book requires a background in electrodynamics, quantum mechanics, and statistical mechanics at the undergraduate level. It will be a valuable reference for advanced undergraduates and graduate students of physics, engineering, and applied mathematics. Features: Contains discussions of the basic principles of quantum optics and its importance to lasers, quantum information, and quantum computation. Provides references and a further reading list to additional scientific literature so that readers can use the book as a starting point to then follow up with a more advanced treatment of the topics covered. Requires only a basic background in undergraduate electrodynamics, quantum mechanics, and statistical mechanics.

Nanostructures and Nanotechnology Douglas Natelson, 2015-06-18. A carefully developed textbook focusing on the fundamental principles of nanoscale science and nanotechnology. INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY CHATTOPADHYAY, K. K., BANERJEE, A. N., 2009-12-30. This compact introductory textbook in the emerging discipline of nano science and nanotechnology presents the fundamental principles and techniques to students of science and engineering. The book presents the information in a pedagogically sound manner and is especially designed for students of M Sc Physics and M Tech courses in nanotechnology. With the increasing applications of nanoscience and nanotechnology in the areas of biotechnology, electronics, integrated circuits, chemistry, physics, materials science, etc., the study of nanostructured materials is also becoming a core part of undergraduate and postgraduate courses of many science and engineering disciplines. The book emphasizes the underlying concepts of nanomaterials with neatly drawn diagrams and illustrations. Modern applications are included to highlight the relevance and importance of nanoscience and nanotechnology in everyday life. The book should therefore be of interest to students of several disciplines of science and engineering as well as research scholars. *Molecular Electronics: An Introduction To Theory And Experiment* Elke Scheer, Juan Carlos Cuevas, 2010-06-23. This book provides a comprehensive overview of the rapidly developing field of molecular electronics. It focuses on our present understanding of the electrical conduction in single molecule circuits and provides a thorough introduction to the experimental techniques and theoretical concepts. It will also constitute as the first textbook like introduction to both the experiment and theory of electronic transport through single atoms and molecules. In this sense, this publication will prove invaluable to both researchers and students interested in the field of nanoelectronics and nanoscience in general. *Molecular Electronics* is self-contained and unified in its presentation. It may be used as a textbook on nanoelectronics by graduate students and advanced undergraduates studying physics and chemistry. In addition, included are previously unpublished material that will help researchers gain a deeper understanding into the basic concepts involved in

the field of molecular electronics **Nanoelectronics** Khurshed Ahmad Shah, 2025-10-21 The book covers the latest advancements in the field of nanoelectronics interaction of light with matter optical properties surface plasmons nanophotonic and plasmonic applications nanomaterials engineering in nanoelectronics fabrication techniques and applications It presents the structure properties and device applications of carbon nanotubes graphene and silicene The book further includes topics on perovskites and applications quantum dots for optoelectronic sensing devices computing applications and advanced applications in diagnostic and therapeutic tools This book Introduces topics on quantum phenomenon in nanoelectronics transistors in modern computing spintronic devices flexible and wearable electronics and case studies and includes topics on development of hybrid material of one dimensional 1D and 2D carbon in nanomedicine computed tomography ultrasound and stapled peptides drug Presents physical and electrical properties of nanoscale materials applications of carbon nanotubes such as batteries supercapacitors biosensors photodetectors and field emission sources and topics on the surface plasmon resonance nanolasers nanoantennas photonic crystals and luminescent materials Discusses quantum dots quantum electronic devices nanosensors quantum computing device applications of perovskite materials spintronics drug delivery and gene therapy applications and the scaling laws in nanoelectronics materials for nano FET high speed computing and advanced nanoscale FET architectures Highlights recent developments in the field of nanoscale devices based on graphene and silicene such as biosensing and gas sensing thermoelectric devices and optoelectronic applications Explains the basic quantum theory pizelectricity in zinc oxide quantum dots and nanosensing includes the topics on data storage and quantum logic gates It is primarily written for senior undergraduates graduate students and academic researchers in the fields including physics computers nanoelectronics electrical engineering electronics and communications engineering nanoscience and nanotechnology *Quantum Statistical Field Theory* Norman J. Morgenstern Horing, 2017-09-22 This book provides an introduction to the methods of coupled quantum statistical field theory and Green s functions The methods of coupled quantum field theory have played a major role in the extensive development of nonrelativistic quantum many particle theory and condensed matter physics This introduction to the subject is intended to facilitate delivery of the material in an easily digestible form to advanced undergraduate physics majors at a relatively early stage of their scientific development The main mechanism to accomplish this is the early introduction of variational calculus and the Schwinger Action Principle accompanied by Green s functions Important achievements of the theory in condensed matter and quantum statistical physics are reviewed in detail to help develop research capability These include the derivation of coupled field Green s function equations of motion for a model electron hole phonon system extensive discussions of retarded thermodynamic and nonequilibrium Green s functions and their associated spectral representations and approximation procedures Phenomenology emerging in these discussions include quantum plasma dynamic nonlocal screening plasmons polaritons linear electromagnetic response excitons polarons phonons magnetic

Landau quantization van der Waals interactions chemisorption etc Considerable attention is also given to low dimensional and nanostructured systems including quantum wells wires dots and superlattices as well as materials having exceptional conduction properties such as Superconductors Superfluids and Graphene

Principles and Methods of Quantum Information Technologies Yoshihisa Yamamoto, Kouichi Semba, 2015-12-30 This book presents the research and development related results of the FIRST Quantum Information Processing Project which was conducted from 2010 to 2014 with the support of the Council for Science Technology and Innovation of the Cabinet Office of the Government of Japan The project supported 33 research groups and explored five areas quantum communication quantum metrology and sensing coherent computing quantum simulation and quantum computing The book is divided into seven main sections Parts I through V which consist of twenty chapters focus on the system and architectural aspects of quantum information technologies while Parts VI and VII which consist of eight chapters discuss the superconducting quantum circuit semiconductor spin and molecular spin technologies Readers will be introduced to new quantum computing schemes such as quantum annealing machines and coherent Ising machines which have now arisen as alternatives to standard quantum computers and are designed to successfully address NP hard NP complete combinatorial optimization problems which are ubiquitous and relevant in our modern life The book offers a balanced mix of theory based and experimentation based chapters written by leading researchers Extensive information is provided on Quantum simulation which focuses on the implementation of various many body Hamiltonians in a well controlled physical system Quantum key distribution Quantum repeaters and quantum teleportation which are indispensable technologies for building quantum networks with various advanced applications and require far more sophisticated experimental techniques to implement

Theory of Quantum Transport at Nanoscale Dmitry Ryndyk, 2015-12-08 This book is an introduction to a rapidly developing field of modern theoretical physics the theory of quantum transport at nanoscale The theoretical methods considered in the book are in the basis of our understanding of charge spin and heat transport in nanostructures and nanostructured materials and are widely used in nanoelectronics molecular electronics spin dependent electronics spintronics and bio electronics The book is based on lectures for graduate and post graduate students at the University of Regensburg and the Technische Universität Dresden TU Dresden The first part is devoted to the basic concepts of quantum transport Landauer Bttiker method and matrix Green function formalism for coherent transport Tunneling Transfer Hamiltonian and master equation methods for tunneling Coulomb blockade vibrons and polarons The results in this part are obtained as possible without sophisticated techniques such as nonequilibrium Green functions which are considered in detail in the second part A general introduction into the nonequilibrium Green function theory is given The approach based on the equation of motion technique as well as more sophisticated one based on the Dyson Keldysh diagrammatic technique are presented The main attention is paid to the theoretical methods able to describe the nonequilibrium at finite voltage electron transport through interacting nanosystems

specifically the correlation effects due to electron electron and electron vibron interactions *Topics In Nanoscience - Part I: Basic Views, Complex Nanosystems: Typical Results And Future* Wolfram Schommers,2021-12-17 With the development of the scanning tunneling microscope nanoscience became an important discipline Single atoms could be manipulated in a controlled manner and it became possible to change matter at its ultimate level it is the level on which the properties of matter emerge This possibility enables to construct and to produce devices materials etc with very small sizes and completely new properties That opens up new perspectives for technology and is in particular relevant in connection with nano engineering Nanosystems are unimaginably small and very fast No doubt this is an important characteristic But there is another feature possibly more relevant in connection with nanoscience and nanotechnology The essential point here is that we work at the ultimate level This is the smallest level at which the properties of our world emerge at which functional matter can exist In particular at this level biological individuality comes into existence This situation can be expressed in absolute terms This is not only the strongest material ever made this is the strongest material it will ever be possible to make D Ratner and M Ratner Nanotechnology and Homeland Security This is a very general statement All aspects of matter are concerned here Through the variation of the composition various forms of matter emerge with different items Nanosystems are usually small but they offer nevertheless the possibility to vary the structure of atomic molecular ensembles creating a diversity of new material specific properties A large variety of experimental possibilities come into play and flexible theoretical tools are needed at the basic level This is reflected in the different disciplines In nanoscience and nanotechnology we have various directions Materials science functional nanomaterials nanoparticles food chemistry medicine with brain research quantum and molecular computing bioinformatics magnetic nanostructures nano optics nano electronics etc The properties of matter which are involved within these nanodisciplines are ultimate in character i e their characteristic properties come into existence at this level The book is organized in this respect **Nanothermites** Eric Lafontaine,Marc Comet,2016-07-14 The recent introduction of the nano dimension to pyrotechnics has made it possible to develop a new family of highly reactive substances nanothermites These have a chemical composition that is comparable to that of thermites at submillimeter or micrometric granulometry but with a morphology having a much increased degree of homogeneity This book discusses the methods of preparation of these energetic nanomaterials their specific properties and the different safety aspects inherent in their manipulation *Piezoelectric ZnO Nanostructure for Energy Harvesting, Volume 1* Yamin Leprince-Wang,2015-03-24 Over the past decade ZnO as an important II VI semiconductor has attracted much attention within the scientific community over the world owing to its numerous unique and prosperous properties This material considered as a future material especially in nanostructural format has aroused many interesting research works due to its large range of applications in electronics photonics acoustics energy and sensing The bio compatibility piezoelectricity low cost fabrication make ZnO nanostructure a very promising material for energy harvesting

Electrostatic Kinetic Energy Harvesting Philippe Basset,Elena Blokhina,Dimitri Galayko,2016-03-03 Harvesting kinetic energy is a good opportunity to power wireless sensor in a vibratory environment Besides classical methods based on electromagnetic and piezoelectric mechanisms electrostatic transduction has a great perspective in particular when dealing with small devices based on MEMS technology This book describes in detail the principle of such capacitive Kinetic Energy Harvesters based on a spring mass system Specific points related to the design and operation of kinetic energy harvesters KEHs with a capacitive interface are presented in detail advanced studies on their nonlinear features typical conditioning circuits and practical MEMS fabrication *Principles of Nanoscience and Molecular Engineering* René M.

Overney,2025-09-05 Introductory resource on nanoscience and molecular engineering stressing the interdisciplinary nature of the field *Principles of Nanoscience and Molecular Engineering* introduces nanoscale principles in molecular engineering providing hands on experience and stressing the interdisciplinary nature of this field The book integrates phenomenological knowledge of material and transport properties with atomistic and molecular theories bridging the gap between unbound classical three dimensional space and the constrained nanorealm The book challenges conventional wisdom derived from anecdotal experiences and fosters an understanding of nanoscale molecular collective phenomena that do not violate classical physical laws but rather expand upon them The surprise exotic awe is replaced by improved insight into the workings of atoms and molecules under interfacial dimensional and size constraints Readers will find detailed insights on molecular phase behavior under confinement the atom model and wave equation quantum mechanics the electronic structure of molecules and matter molecular modes and energetic properties self assembly and statical mechanics of pair interactions in gases Written by a highly qualified professor in chemical engineering with significant research contributions to the field *Principles of Nanoscience and Molecular Engineering* includes information on Shared perceptions of our world and their shortcomings applied to the nanoscale specifically to transport properties Structured condensed systems affected by interfaces and size constraints examining the effect of non interacting solid interfaces on liquid phases and free surfaces of solid crystal lattice arrangements The liquid condensed state highlighting boundary conditions in thermally equilibrated systems Electronic transport in relation to the electronic structure of molecules focusing on the movement of electrons through lower dimensional systems *Principles of Nanoscience and Molecular Engineering* serves as an excellent introductory resource on the subject for readers studying or working in related fields **Resonant Tunneling Diode Photonics** Charlie

Ironside,Bruno Romeira,José Figueiredo,2019-11-11 This book brings together two broad themes that have generated a great deal of interest and excitement in the scientific and technical community in the last 100 years or so quantum tunnelling and nonlinear dynamical systems It applies these themes to nanostructured solid state heterostructures operating at room temperature to gain insight into novel photonic devices systems and applications *21st Century Nanoscience - A Handbook* Klaus D. Sattler,2020-11-26 21st Century Nanoscience A Handbook Nanophotonics Nanoelectronics and

Nanoplasmonics Volume 6 will be the most comprehensive up to date large reference work for the field of nanoscience Handbook of Nanophysics by the same editor published in the fall of 2010 and was embraced as the first comprehensive reference to consider both fundamental and applied aspects of nanophysics This follow up project has been conceived as a necessary expansion and full update that considers the significant advances made in the field since 2010 It goes well beyond the physics as warranted by recent developments in the field This sixth volume in a ten volume set covers nanophotonics nanoelectronics and nanoplasmonics Key Features Provides the most comprehensive up to date large reference work for the field Chapters written by international experts in the field Emphasises presentation and real results and applications This handbook distinguishes itself from other works by its breadth of coverage readability and timely topics The intended readership is very broad from students and instructors to engineers physicists chemists biologists biomedical researchers industry professionals governmental scientists and others whose work is impacted by nanotechnology It will be an indispensable resource in academic government and industry libraries worldwide The fields impacted by nanophysics extend from materials science and engineering to biotechnology biomedical engineering medicine electrical engineering pharmaceutical science computer technology aerospace engineering mechanical engineering food science and beyond

Thermodynamics in the Quantum Regime Felix Binder, Luis A. Correa, Christian Gogolin, Janet Anders, Gerardo Adesso, 2019-04-01 Quantum Thermodynamics is a novel research field which explores the emergence of thermodynamics from quantum theory and addresses thermodynamic phenomena which appear in finite size non equilibrium and finite time contexts Blending together elements from open quantum systems statistical mechanics quantum many body physics and quantum information theory it pinpoints thermodynamic advantages and barriers emerging from genuinely quantum properties such as quantum coherence and correlations Owing to recent experimental efforts the field is moving quickly towards practical applications such as nano scale heat devices or thermodynamically optimised protocols for emergent quantum technologies Starting from the basics the present volume reviews some of the most recent developments as well as some of the most important open problems in quantum thermodynamics The self contained chapters provide concise and topical introductions to researchers who are new to the field Experts will find them useful as a reference for the current state of the art In six sections the book covers topics such as quantum heat engines and refrigerators fluctuation theorems the emergence of thermodynamic equilibrium thermodynamics of strongly coupled systems as well as various information theoretic approaches including Landauer's principle and thermal operations It concludes with a section dedicated to recent quantum thermodynamics experiments and experimental prospects on a variety of platforms ranging from cold atoms to photonic systems and NV centres

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