

Lecture Notes in Physics

Tobias Brandes (Ed.)

# Low-Dimensional Systems

Interactions  
and Transport Properties

Workshop,  
Hamburg,  
Germany 1999



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# Lowdimensional Systems Interactions And Transport Properties

**D. Baeriswyl, L. Degiorgi**



## **Lowdimensional Systems Interactions And Transport Properties:**

**Low-Dimensional Systems** Tobias Brandes,2014-03-12 Experimental progress over the past few years has made it possible to test a n ber of fundamental physical concepts related to the motion of electrons in low dimensions The production and experimental control of novel structures with typical sizes in the sub micrometer regime has now become possible In parti lar semiconductors are widely used in order to con ne the motion of electrons in two dimensional heterostructures The quantum Hall e ect was one of the rst highlights of the new physics that is revealed by this con nement In a further step of the technological development in semiconductor heterostructures other arti cial devices such as quasi one dimensional quantum wires and quantum dots arti cial atoms have also been produced These structures again di er very markedly from three and two dimensional systems especially in relation to the transport of electrons and the interaction with light Although the technol ical advances and the experimental skills connected with these new structures are progressing extremely fast our theoretical understanding of the physical e ects such as the quantum Hall e ect is still at a very rudimentary level In low dimensional structures the interaction of electrons with one another and with other degrees of freedoms such as lattice vibrations or light gives rise to new phenomena that are very di erent from those familiar in the bulk ma rial The theoretical formulation of the electronic transport properties of small devices may be considered well established provided interaction processes are neglected

*Low-Dimensional Systems* Tobias Brandes,2008-01-11 Experimental progress over the past few years has made it possible to test a n ber of fundamental physical concepts related to the motion of electrons in low dimensions The production and experimental control of novel structures with typical sizes in the sub micrometer regime has now become possible In parti lar semiconductors are widely used in order to con ne the motion of electrons in two dimensional heterostructures The quantum Hall e ect was one of the rst highlights of the new physics that is revealed by this con nement In a further step of the technological development in semiconductor heterostructures other arti cial devices such as quasi one dimensional quantum wires and quantum dots arti cial atoms have also been produced These structures again di er very markedly from three and two dimensional systems especially in relation to the transport of electrons and the interaction with light Although the technol ical advances and the experimental skills connected with these new structures are progressing extremely fast our theoretical understanding of the physical e ects such as the quantum Hall e ect is still at a very rudimentary level In low dimensional structures the interaction of electrons with one another and with other degrees of freedoms such as lattice vibrations or light gives rise to new phenomena that are very di erent from those familiar in the bulk ma rial The theoretical formulation of the electronic transport properties of small devices may be considered well established provided interaction processes are neglected

**Handbook of Nanophysics** Klaus D. Sattler,2010-09-17 Intensive research on fullerenes nanoparticles and quantum dots in the 1990s led to interest in nanotubes and nanowires in subsequent years Handbook of Nanophysics Nanotubes and Nanowires focuses on the fundamental physics and latest applications of these

important nanoscale materials and structures Each peer reviewed chapter contains a broad **Theory of Transport Properties of Semiconductor Nanostructures** Eckehard Schöll,2013-11-27 Recent advances in the fabrication of semiconductors have created almost unlimited possibilities to design structures on a nanometre scale with extraordinary electronic and optoelectronic properties The theoretical understanding of electrical transport in such nanostructures is of utmost importance for future device applications This represents a challenging issue of today's basic research since it requires advanced theoretical techniques to cope with the quantum limit of charge transport ultrafast carrier dynamics and strongly nonlinear high field effects This book which appears in the electronic materials series presents an overview of the theoretical background and recent developments in the theory of electrical transport in semiconductor nanostructures It contains 11 chapters which are written by experts in their fields Starting with a tutorial introduction to the subject in Chapter 1 it proceeds to present different approaches to transport theory The semiclassical Boltzmann transport equation is in the centre of the next three chapters Hydrodynamic moment equations Chapter 2 Monte Carlo techniques Chapter 3 and the cellular automaton approach Chapter 4 are introduced and illustrated with applications to nanometre structures and device simulation A full quantum transport theory covering the Kubo formalism and nonequilibrium Green's functions Chapter 5 as well as the density matrix theory Chapter 6 is then presented *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 Physics and Chemistry of Nano-structured Materials Shihe Yang,2003-09-02 The development of nanostructured materials represents a new and fast evolving application of recent research in physics and chemistry Novel experimental tools coupled with new theory have made this possible Topics covered in this book include nanocrystals semiconductor heterostructures nanotubes nanowires and manipulation and fabrication techniques The core of the book consists of ten lectures by five distinguished researchers Paul Alivisatos D D Awschalom Sumio Iijima Charles Lieber and Phaedon Avouris presented at an Advanced Study Institute in Hong Kong in January 1999 It

should interest materials physicists and chemists as well as materials scientists with an interest in the growth and characterisation of sophisticated materials

**Physical Properties of Low-Dimensional Systems** Levente Máthé, 2025-10-02 This book provides an in depth theoretical exploration of quantum transport and optical properties in nanodevices focusing on quantum dots topological superconducting nanowires and graphene It is designed for graduate students and researchers seeking to understand these systems and their implications for advancing nanophotonic and nanoelectronic technologies Beginning with foundational concepts in quantum transport the book covers key phenomena such as the Coulomb blockade the Kondo effect and the physics of Majorana fermions and Majorana bound states A review of graphene s electronic properties and the optical characteristics of quantum dots is also included establishing a basis for the more advanced topics that follow The book explores a nanojunction model where a quantum dot is integrated into a semiconducting superconducting heterostructure that hosts Majorana bound states The study investigates Majorana induced phonon assisted quantum tunneling in topological superconducting nanowires under magnetic flux This model offers valuable insights for future experiments aimed at detecting Majorana bound states with implications for topological quantum computing Additionally the book explores quantum transport in a system where a semiconductor quantum dot is embedded between monolayer graphene leads Applying an external magnetic field enables spin polarized transport providing an ideal platform for studying many body quantum phenomena such as the Kondo effect Using nonequilibrium Green s function formalism this section highlights how graphene s electronic properties can drive next generation nanoelectronic devices Beyond transport the book also examines the optical properties of quantum dots focusing on their linear and nonlinear characteristics Perturbation theory is employed to study absorption coefficients and refractive index changes in two level quantum dot systems with potential applications in optoelectronics and photonics Throughout complex mathematical treatments are presented in an accessible manner ensuring that even readers with a foundational understanding of nanophysics can engage with the material This book serves as a valuable resource for researchers and students working in the fields of nanophysics nanoelectronics and quantum device research It deepens theoretical understanding of these systems but also offers practical insights into their experimental realization and technological potential

**Strong Interactions in Low Dimensions** D. Baeriswyl, L. Degiorgi, 2007-09-29 This book provides an attempt to convey the colorful facets of condensed matter systems with reduced dimensionality Some of the specific features predicted for interacting one dimensional electron systems such as charge and spin density waves have been observed in many quasi one dimensional materials The two dimensional world is even richer besides d wave superconductivity and the Quantum Hall Effect perhaps the most spectacular phases explored during the last two decades many collective charge and spin states have captured the interest of researchers such as charge stripes or spontaneously generated circulating currents Recent years have witnessed important progress in material preparation measurement techniques and theoretical methods Today larger and better

samples higher flux for neutron beams advanced light sources better resolution in electron spectroscopy new computational algorithms and the development of field theoretical approaches allow an in depth analysis of the complex many body behaviour of low dimensional materials The epoch when simple mean field arguments were sufficient for describing the gross features observed experimentally is definitely over The Editors aim is to thoroughly explain a number of selected topics the application of dynamical probes such as neutron scattering optical absorption and photoemission as well as transport studies both electrical and thermal Some of the more theoretical chapters are directly relevant for experiments such as optical spectroscopy transport in one dimensional models and the phenomenology of charge inhomogeneities in layered materials while others discuss more general topics and methods for example the concept of a Luttinger liquid and bosonization or duality transformations both promising tools for treating strongly interacting many body systems

*Handbook on the Physics and Chemistry of Rare Earths* Vitalij K. Pecharsky, Jean-Claude G. Bunzli, 2020-11-11 Handbook on the Physics and Chemistry of Rare Earths Including Actinides Volume 58 the latest release in this continuous series that covers all aspects of rare earth science including chemistry life sciences materials science and physics presents interesting chapters on Forensic applications of rare earth materials and Rare earths the seventeen position nob Presents up to date overviews and new developments in the field of rare earths covering both their physics and chemistry Contains individual chapters that are comprehensive and broad along with critical reviews Provides contributions from highly experienced invited experts

**Low-Dimensional Materials** Hui-Ming Cheng, Dai-Ming Tang, Xiaolong Zou, Lili Zhang, 2024-10-05 Low Dimensional Materials Bridging the Fundamental Principles to Practice Applications provides an overview of research on low dimensional materials devices and their applications There are seven chapters in the book starting from the basic quantum theory in chapter one to the control and characterization of the unique structures chapters two and four to the relation of the physical and chemical properties with structures chapter five and to the practical and promising applications in energy information and health chapter six before conclusions and future outlook in chapter seven Discusses the whole field of low dimensional materials from quantum mechanics and low dimensional effects to structure property relations various methods of fabrication and assembly techniques and a characterization of atomic and interface structures Covers a wide range of topics making it a map for readers to understand the fundamentals of low dimensional materials Written with a bottom up approach with a solid foundation of quantum mechanics thermodynamics and energy transport in low dimensional systems

Elements of Quantum Information Wolfgang P. Schleich, Herbert Walther, 2007-06-27 Elements of Quantum Information introduces the reader to the fascinating field of quantum information processing which lives on the interface between computer science physics mathematics and engineering This interdisciplinary branch of science thrives on the use of quantum mechanics as a resource for high potential modern applications With its wide coverage of experiments applications and specialized topics all written by renowned experts Elements of Quantum Information provides an indispensable up to date account of the state of

the art of this rapidly advancing field and takes the reader straight up to the frontiers of current research. The articles have first appeared as a special issue of the journal *Fortschritte der Physik* Progress of Physics. Since then they have been carefully updated. The book will be an inspiring source of information and insight for anyone researching and specializing in experiments and theory of quantum information.

### **Field Theories for Low-Dimensional Condensed Matter Systems**

Guiseppe Morandi, Pasquale Sodano, Arturo Tagliacozzo, Valerio Tognetti, 2013-03-14. This book is especially addressed to young researchers in theoretical physics with a basic background in Field Theory and Condensed Matter Physics. The topics were chosen so as to offer the largest possible overlap between the two expertises, selecting a few key problems in Condensed Matter Theory which have been recently revisited within a field theoretic approach. The presentation of the material is aimed not only at providing the reader with an overview of this exciting frontier area of modern theoretical physics but also at elucidating most of the tools needed for a technical comprehension of the many papers appearing in current issues of physics journals and hopefully to enable the reader to tackle research problems in this area of physics. This makes the material a live creature while not pretending it to be exhaustive; it is tutorial enough to be useful to young researchers as a starting point in any one of the topics covered in the book.

### **Introduction To Condensed Matter**

**Physics, Volume 1** Duan Feng, Guojun Jin, 2005-07-04. This is volume 1 of a two volume book that presents an excellent comprehensive exposition of the multifaceted subjects of modern condensed matter physics unified within an original and coherent conceptual framework. Traditional subjects such as band theory and lattice dynamics are tightly organized in this framework while many new developments emerge spontaneously from it. In this volume, basic concepts are emphasized; usually they are intuitively introduced then more precisely formulated and compared with correlated concepts. A plethora of new topics such as quasicrystals, photonic crystals, GMR, TMR, CMR, high  $T_c$  superconductors, Bose-Einstein condensation etc. are presented with sharp physical insights. Bond and band approaches are discussed in parallel, breaking the barrier between physics and chemistry. A highly accessible chapter is included on correlated electronic states rarely found in an introductory text. Introductory chapters on tunneling, mesoscopic phenomena and quantum confined nanostructures constitute a sound foundation for nanoscience and nanotechnology. The text is profusely illustrated with about 500 figures.

Organic and Inorganic Low-Dimensional Crystalline Materials Pierre Delhaes, Marc Drillon, 2013-12-01. The research of unitary concepts in solid state and molecular chemistry is of current interest for both chemist and physicist communities. It is clear that due to their relative simplicity, low dimensional materials have attracted most of the attention. Thus many non-trivial problems were solved in chain systems giving some insight into the behavior of real systems which would otherwise be untractable. The NATO Advanced Research Workshop on Organic and Inorganic Low Dimensional Crystalline Materials was organized to review the most striking electronic properties exhibited by organic and inorganic systems whose space dimensionality ranges from zero D to one 1D and to discuss related scientific and technological potentials. The initial objectives of this Workshop

were respectively i To research unitary concepts in solid state physics in particular for one dimensional compounds ii To reinforce through a close coupling between theory and experiment the interplay between organic and inorganic chemistry on the one hand and solid state physics on the other iii To get a salient understanding of new low dimensional materials showing exotic physical properties in conjunction with structural features

*Low Dimensional Properties Of Solids: Nobel Jubilee Symposium - Proceedings Of The Nobel Jubilee Symposium* T Claeson, M Jonson, 1993-03-08 Rarely do so many leading physicists attend one symposium No less than nine Nobel laureates and some 40 other top researchers gathered for this symposium and this book contains the material presented in invited talks as well as the posters The 34 papers are organised into three groups corresponding to various aspects of low dimensional physics of solids

### **New Horizons in**

**Low-Dimensional Electron Systems** H. Aoki, M. Tsukada, M. Schlüter, F.A. Lévy, 2012-12-06 In Bird of Passage by Rudolf Peierls we find a paragraph in which he describes his Cambridge days in the 1930s On these relativistic field theory problems my main contacts were Dirac and the younger theoreticians These included in particular Nevill now Sir Nevill Mott perhaps the friendliest among many kind and friendly people we met then Professor Kamimura became associated with Sir Rudolf Peierls in the 1950s when he translated with his colleagues Peierls's 1955 textbook Quantum Theory of Solids into Japanese This edition to which Sir Rudolf himself contributed a preface benefitted early generations of Japanese solid state physicists Later in 1974 5 during a sabbatical year spent at the Cavendish Laboratory Professor Kamimura met and began a long association with Sir Nevill Mott In particular they developed ideas for disordered systems One of the outcomes is a paper coauthored by them on ESR induced variable range hopping in doped semiconductors A series of works on disordered systems together with those on two dimensional systems have served as building blocks for Physics of Interacting Electrons in Disordered Systems in the International Series of Monographs on Physics coauthored by Aoki and published in 1989 by the Oxford University Press Soon after Professor Kamimura obtained a D Sc in 1959 for the work on the ligand field theory under the supervision of Masao Kotani his strong connections in the international physical community began when he worked at the Bell Telephone Laboratories in 1961 64

### **The Physics of Organic Superconductors and Conductors** Andrei

Lebed, 2008-03-26 This bang up to date volume contains the distilled wisdom of some of the world's leading minds on the subject Inside there is a treasure trove of general tutorial and topical reviews written by leading researchers in the area of organic superconductors and conductors The papers hail from all over the world as far afield as the USA and Australia They cover contemporary topics such as unconventional superconductivity non Fermi liquid properties and the quantum Hall effect

### **Physics Of Low-dimensional Systems - Proceedings Of Nobel Symposium 73** Stig Lundqvist, Nils Robert

Nilsson, 1989-07-01 List of Contributors P W Anderson S Tanaka C W Chu Y H Kim T V Ramakrishnan G Wendin G Baskaran H Fukuyama Y Hasegawa A Zawadowski A A Abrikosov A I Buzdin V L Ginzburg S Barisic I Batistic E J Mele L Dzyaloshinskii L A Falkovsky J R Schrieffer D J Scalapino A I Larkin K W Becker P Fulde S A Trugman F C Zhang K A Chao G Z Wei D J Rome



et al J Bardeen M Sinclair S M Girvin D P Arovas P B Wiegmann and others     The Electron Liquid Paradigm in Condensed Matter Physics G. Vignale,G.F. Giuliani,2005-02-03 The electron liquid paradigm is at the basis of most of our current understanding of the physical properties of electronic systems Quite remarkably the latter are nowadays at the intersection of the most exciting areas of science materials science quantum chemistry nano electronics biology and quantum computation Accordingly its importance can hardly be overestimated During the past 20 years the field has witnessed momentous developments which are partly covered in this new volume Advances in semiconductor technology have allowed the realizations of ultra pure electron liquids whose density unlike that of the ones spontaneously occurring in nature can be tuned by electrical means allowing a systematic exploration of both strongly and weakly correlated regimes Most of these system are two or even one dimensional and can be coupled together in the form of multi layers or multi wires opening vast observational possibilities On the theoretical side quantum Monte Carlo methods have allowed an essentially exact determination of the ground state energy of the electron liquid and have provided partial answers to the still open question of the structure of its phase diagram Starting from the 1980s some truly revolutionary concepts have emerged which are well represented in this volume     **Physical Model and Applications of High-Efficiency Electro-Optical Conversion Devices - Volume II** Feng Chi,Qiang Xu,Dan Luo,2023-03-31

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