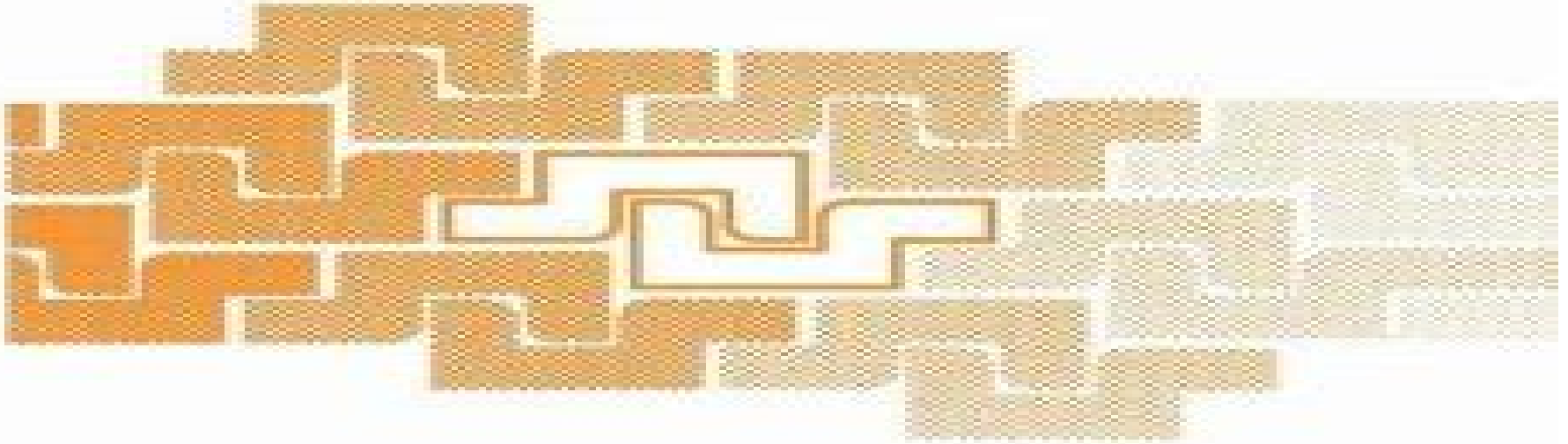

# Quantum Transport in Semiconductor Submicron Structures

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# Quantum Transport In Semiconductor Submicron Structures

Harold L. Grubin,David K. Ferry,C. Jacoboni

**Quantum Transport In Semiconductor Submicron Structures:**

*Quantum Transport in Semiconductor Submicron Structures* B. Kramer,2011-09-20 The articles in this book have been selected from the lectures of a NATO Advanced Study Institute held at Bad Lauterberg Germany in August 1995 Internationally well known researchers in the field of mesoscopic quantum physics provide insight into the fundamental physics underlying the mesoscopic transport phenomena in structured semiconductor inversion layers In addition some of the most recent achievements are reported in contributed papers The aim of the volume is not to give an overview over the field Instead emphasis is on interaction and correlation phenomena that turn out to be of increasing importance for the understanding of the phenomena in the quantum Hall regime and in the transport through quantum dots The present status of the quantum Hall experiments and theory is reviewed As a key example for non Fermi liquid behavior the Luttinger liquid is introduced including some of the most recent developments It is not only of importance for the fractional quantum Hall effect but also for the understanding of transport in quantum wires Furthermore the chaotic and the correlation aspects of the transport in quantum dot systems are described The status of the experimental work in the area of persistent currents in semiconductor systems is outlined The construction of one of the first single electron transistors is reported The theoretical approach to mesoscopic transport presently a most active area is treated and some aspects of time dependent transport phenomena are also discussed **Theory of Transport Properties of Semiconductor Nanostructures** Eckehard Schöll,1997-12-31 Recent advances in the fabrication of semiconductors have created almost un limited possibilities to design structures on a nanometre scale with extraordinary electronic and optoelectronic properties The theoretical understanding of elec trical 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 ef fects This book which appears in the electronic materials series presents an over view 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 au tomaton 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 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 *Quantum Transport and Dissipation* Thomas Dittrich,1998-03-04 The increasing emphasis and importance of mesoscopic systems for tomorrow s high tech electronics industry as well as a growing research interest in the subject has given rise to the need for a modern introductory text at the graduate level This book aims to provide the necessary theory and tools to carry out research into the various aspects of the subject It starts with a chapter on the theory of quantum transport giving a survey of the basic theory used in transport phenomena including scattering linear response theory weak localization conductance fluctuations and the Landauer B ttiker formalism Various aspects of chaos in quantum systems as well as dissipative quantum systems are discussed Other topics of importance such as single electron tunneling driven bistable systems quantized transport and electron liquids are also covered in detail Graduate students as well as newcomers to this exciting and expanding field will find this work useful to adopt the necessary theory and overview required to go deeper into the original literature and to carry out research The Physics of Submicron Semiconductor Devices Harold L. Grubin,David K. Ferry,C. Jacoboni,2013-11-11 The papers contained in the volume represent lectures delivered as a 1983 NATO ASI held at Urbino Italy The lecture series was designed to identify the key submicron and ultrasubmicron device physics transport materials and contact issues Nonequilibrium transport quantum transport interfacial and size constraints issues were also highlighted The ASI was supported by NATO and the European Research Office H L Grubin D K Ferry C Jacoboni v CONTENTS MODELLING OF SUB MICRON DEVICES 1 E Constant BOLTZMANN TRANSPORT EQUATION 33 K Hess TRANSPORT AND MATERIAL CONSIDERATIONS FOR SUBMICRON DEVICES 45 H L Grubin EPITAXIAL GROWTH FOR SUB MICRON STRUCTURES 179 C E C Wood INSULATOR SEMICONDUCTOR INTERFACES 195 C W Wilms en THEORY OF THE ELECTRONIC STRUCTURE OF SEMICONDUCTOR SURFACES AND INTERFACES 223 C Calandra DEEP LEVELS AT COMPOUND SEMICONDUCTOR INTERFACES 253 W Monch ENSEMBLE MONTE CARLO TECHNIqUES 289 C Jacoboni NOISE AND DIFFUSION IN SUBMICRON STRUCTURES 323 L Reggiani SUPERLATTICES 361 K Hess SUBMICRON LITHOGRAPHY 373 C D W Wilkinson and S P Beaumont QUANTUM EFFECTS IN DEVICE STRUCTURES DUE TO SUBMICRON CONFINEMENT IN ONE DIMENSION 401 B D McCombe vii viii CONTENTS PHYSICS OF HETEROSTRUCTURES AND HETEROSTRUCTURE DEVICES 445 P J Price CORRELATION EFFECTS IN SHORT TIME NONS TAT I ONARY TRANSPORT 477 J J Niez DEVICE DEVICE INTERACTIONS 503 D K Ferry QUANTUM TRANSPORT AND THE WIGNER FUNCTION 521 G J Iafrate FAR INFRARED MEASUREMENTS OF VELOCITY OVERSHOOT AND HOT ELECTRON DYNAMICS IN SEMICONDUCTOR DEVICES 577 S J Allen Jr **Quantum Transport in Semiconductors**

David K. Ferry,Carlo Jacoboni,2013-06-29 The majority of the chapters in this volume represent a series of lectures that were given at a workshop on quantum transport in ultrasmall electron devices held at San Miniato Italy in March 1987 These have of course been extended and updated during the period that has elapsed since the workshop was held and have been supplemented with additional chapters devoted to the tunneling process in semiconductor quantum well structures The aim of this work is to review and present the current understanding in nonequilibrium quantum transport appropriate to semiconductors Gen erally the field of interest can be categorized as that appropriate to inhomogeneous transport in strong applied fields These fields are most likely to be strongly varying in both space and time Most of the literature on quantum transport in semiconductors or in metallic systems for that matter is restricted to the equilibrium approach in which spectral densities are maintained as semiclassical energy conserving delta functions or perhaps incorporating some form of collision broadening through a Lorentzian shape and the distribution functions are kept in the equilibrium Fermi Dirac form The most familiar field of nonequilibrium transport at least for the semiconductor world is that of hot carriers in semiconductors

**Solid State Theory** Ulrich Rössler,2013-06-29 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 Tc 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 **Physics of Low-Dimensional Semiconductor Structures** Paul N. Butcher,Norman H. March,Mario P. Tosi,2013-11-11 Presenting the latest advances in artificial structures this volume discusses in depth the structure and electron transport mechanisms of quantum wells superlattices quantum wires and quantum dots It will serve as an invaluable reference and review for researchers and graduate students in solid state physics materials science and electrical and electronic engineering **Physics and Technology of Submicron Structures** Österreichische Physikalische Gesellschaft,1988-10-12 This volume presents a discussion of the latest results in the physics of low dimensional structures At the winter school major breakthroughs were reported and some of the excitement of the participants is reflected in the contributions The topics treated range from the fabrication of microstructures and the physical background of future semiconductor devices to vertical transport in nanostructures universal conductance fluctuations and the transition from two dimensional to one dimensional conduction in semiconductor structures

**Solitons** R. MacKenzie,M.B. Paranjape,W.J. Zakrzewski,2000 Solitons were discovered by John Scott Russel in 1834 and have intrigued scientists and mathematicians ever since They have been the subject of a large body of research not only in mathematics and physics but also engineering biology and other disciplines This volume comprises the presentations at an

interdisciplinary workshop held at Querns University in Kingston Ontario It includes chapters on mathematical and numerical aspects of solitons recent developments in string theory and applications of solitons in such areas as nuclear and particle physics cosmology and condensed matter physics **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 **Correlated Fermions and Transport in Mesoscopic Systems** Thierry Martin,Gilles Montambaux,J. Thanh Van Tran,1996 *Scientific and Technical Aerospace Reports* ,1995 Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database The Physics of Submicron Semiconductor Devices (Nato Asi Series. Series B. Physics, Vol 180) Harold L. Grubin,David K. Ferry,C. Jacoboni,1988 The papers contained in the volume represent lectures delivered as a 1983 NATO ASI held at Urbino Italy The lecture series was designed to identify the key submicron and ultrasubmicron device physics transport materials and contact issues Nonequilibrium transport quantum transport interfacial and size constraints issues were also highlighted The ASI was supported by NATO and the European Research Office H L Grubin D K Ferry C Jacoboni v CONTENTS MODELLING OF SUB MICRON DEVICES 1 E Constant BOLTZMANN TRANSPORT EQUATION 33 K Hess TRANSPORT AND MATERIAL CONSIDERATIONS FOR SUBMICRON DEVICES 45 H L Grubin EPITAXIAL GROWTH FOR SUB MICRON STRUCTURES 179 C E C Wood INSULATOR SEMICONDUCTOR INTERFACES 195 C W Wilms en THEORY OF THE ELECTRONIC STRUCTURE OF SEMICONDUCTOR SURFACES AND INTERFACES 223 C Calandra DEEP LEVELS AT COMPOUND SEMICONDUCTOR INTERFACES 253 W Monch ENSEMBLE MONTE CARLO TECHNIqUES 289 C Jacoboni NOISE AND DIFFUSION IN SUBMICRON STRUCTURES 323 L Reggiani SUPERLATTICES 361 K Hess SUBMICRON LITHOGRAPHY 373 C D W

Wilkinson and S P Beaumont QUANTUM EFFECTS IN DEVICE STRUCTURES DUE TO SUBMICRON CONFINEMENT IN ONE DIMENSION 401 B D McCombe vii viii CONTENTS PHYSICS OF HETEROSTRUCTURES AND HETEROSTRUCTURE DEVICES 445 P J Price CORRELATION EFFECTS IN SHORT TIME NONS TAT I ONARY TRANSPORT 477 J J Niez DEVICE DEVICE INTERACTIONS 503 D K Ferry QUANTUM TRANSPORT AND THE WIGNER FUNCTION 521 G J Iafrate FAR INFRARED MEASUREMENTS OF VELOCITY OVERSHOOT AND HOT ELECTRON DYNAMICS IN SEMICONDUCTOR DEVICES 577 S J Allen Jr Sub-Micron Semiconductor Devices Ashish Raman,Deep Shekhar,Naveen Kumar,2022-05-10 This comprehensive reference text discusses novel semiconductor devices including nanostructure field effect transistors photodiodes high electron mobility transistors and oxide based devices The text covers submicron semiconductor devices device modeling novel materials for devices novel semiconductor devices optimization techniques and their application in detail It covers such important topics as negative capacitance devices surface plasmon resonance devices Fermi level pinning external stimuli based optimization techniques optoelectronic devices and architecture based optimization techniques The book Covers novel semiconductor devices with submicron dimensions Discusses comprehensive device optimization techniques Examines conceptualization and modeling of semiconductor devices Covers circuit and sensor based application of the novel devices Discusses novel materials for next generation devices This text will be useful for graduate students and professionals in fields including electrical engineering electronics and communication engineering materials science and nanoscience *Physical Properties of Ceramic and Carbon Nanoscale Structures* Stefano Bellucci,2011-02-28 This is the second volume in a series of books on selected topics in Nanoscale Science and Technology based on lectures given at the well known INFN schools of the same name The aim of this collection is to provide a reference corpus of suitable introductory material to relevant subfields as they mature over time by gathering the significantly expanded and edited versions of tutorial lectures given over the years by internationally known experts The present set of notes stems in particular from the participation and dedication of prestigious lecturers such as Andrzej Huczko Nicola Pugno Alexander Malesevic Pasquale Onorato and Stefano Bellucci All lectures were subsequently carefully edited and reworked taking into account the extensive follow up discussions A tutorial lecture by Huczko et al shows how a variety of carbon and ceramic nanostructures nanotubes nanowires nanofibres nanorods and nanoencapsulates have in particular great potential for improving our understanding of the fundamental concepts of the roles of both dimensionality and size on physical material properties Bellucci and Onorato provide an extensive and tutorial review of the quantum transport properties in carbon nanotubes encompassing a description of the electronic structure from graphene to single wall nanotubes as well as a discussion of experimental evidence of superconductivity in carbon nanotubes and the corresponding theoretical interpretation In the first contribution by Pugno new ideas on how to design futuristic self cleaning super adhesive and releasable hierarchical smart materials are presented He also reviews the mechanical strength of such nanotubes and

megacables with an eye to the visionary project of a carbon nanotube based space elevator megacable In his second contribution Pugno outlines in detail the role on the fracture strength of thermodynamically unavoidable atomistic defects with different size and shape both numerically andtheoretically for nanotubes and nanotube bundles Focusing on graphitic allotropes the chapter by Bellucci and Malesevic aims to give a taste of the widespread implications carbon nanostructures have on research and applications starting from an historical overview followed by a discussion of the structure and physical properties of carbon nanotubes and graphene in particular in the context of the several different synthesis techniques presently available Spin Electronics David D. Awschalom,Robert A. Buhrman,James M. Daughton,Stephan von Molnár,Michael L. Roukes,2013-06-29 The history of scientific research and technological development is replete with examples of breakthroughs that have advanced the frontiers of knowledge but seldom does it record events that constitute paradigm shifts in broad areas of intellectual pursuit One notable exception however is that of spin electronics also called spintronics magnetoelectronics or magnetronics wherein information is carried by electron spin in addition to or in place of electron charge It is now well established in scientific and engineering communities that Moore s Law having been an excellent predictor of integrated circuit density and computer performance since the 1970s now faces great challenges as the scale of electronic devices has been reduced to the level where quantum effects become significant factors in device operation Electron spin is one such effect that offers the opportunity to continue the gains predicted by Moore s Law by taking advantage of the confluence of magnetics and semiconductor electronics in the newly emerging discipline of spin electronics From a fundamental viewpoine spin polarization transport in a material occurs when there is an imbalance of spin populations at the Fermi energy In ferromagnetic metals this imbalance results from a shift in the energy states available to spin up and spin down electrons In practical applications a ferromagnetic metal may be used as a source of spin polarized electronics to be injected into a semiconductor a superconductor or a normal metal or to tunnel through an insulating barrier

*The Physics of Submicron Semiconductor Devices* Harold L Grubin,David Ferry,C Jacoboni,2014-01-15

*Nonequilibrium Quantum Transport Theory Of Spinful And Topological Systems: A New Perspective And Foundation For Topotronics* Felix A Buot,2024-04-23 This book employs nonequilibrium quantum transport based on the use of mixed Hilbert space representations and real time quantum superfield transport theory to explain various topological phases of systems with entangled chiral degrees of freedom It presents an entirely new perspective on topological systems entanglement induced localization and delocalization integer quantum Hall effect IQHE fractional quantum Hall effect FQHE and its respective spectral zones in the Hofstadter butterfly spectrum A simple and powerful intuitive and wide ranging perspective on chiral transport dynamics **Advances in Research and Applications: Semiconductor Heterostructures and Nanostructures** ,1991-05-01 The explosion of the science of mesoscopic structures is having a great impact on physics and electrical engineering because of the possible applications of these structures in microelectronic and optoelectronic devices

of the future This volume of Solid State Physics consists of two comprehensive and authoritative articles that discuss most of the physical problems that have so far been identified as being of importance in semiconductor nanostructures Much of the volume is tutorial in characture while at the same time time presenting current and vital theoretical and experimental results and a copious reference list so it will be essential reading to all those taking a part in the research and development of this emerging technology

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**Table of Contents Quantum Transport In Semiconductor Submicron Structures**

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