



Quantum Mesoscopic Phenomena and Mesoscopic Devices in Microelectronics

Edited by

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Thierry Dauxois



Quantum Mesoscopic Phenomena And Mesoscopic Devices In Microelectronics:

Quantum Mesoscopic Phenomena and Mesoscopic Devices in Microelectronics Igor O. Kulik, Recai Ellialtıoğlu, 2000 Quantum mechanical laws are well documented at the level of a single or a few atoms and are here extended to systems containing 10² to 10¹⁰ electrons still much smaller than the usual macroscopic objects but behaving in a manner similar to a single atom Besides the purely theoretical interest such systems pose a challenge to the achievement of the ultimate microelectronic applications The present volume presents an up to date account of the physics technology and expected applications of quantum effects in solid state mesoscopic structures Physical phenomena include the Aharonov Bohm effect persistent currents Coulomb blockade and Coulomb oscillations in single electron devices Andreev reflections and the Josephson effect in superconductor normal superconductor systems shot noise suppression in microcontacts and contact resistance quantisation and overall quantum coherence in mesoscopic and nanoscopic structures related to the emerging physics of quantum computation in the solid state environment

Quantum Mesoscopic Phenomena and Mesoscopic Devices in Microelectronics Igor O. Kulik, Recai Ellialtıogamalu, 2012-12-06 Quantum mechanical laws are well documented at the level of a single or a few atoms and are here extended to systems containing 10² to 10¹⁰ electrons still much smaller than the usual macroscopic objects but behaving in a manner similar to a single atom Besides the purely theoretical interest such systems pose a challenge to the achievement of the ultimate microelectronic applications The present volume presents an up to date account of the physics technology and expected applications of quantum effects in solid state mesoscopic structures Physical phenomena include the Aharonov Bohm effect persistent currents Coulomb blockade and Coulomb oscillations in single electron devices Andreev reflections and the Josephson effect in superconductor normal superconductor systems shot noise suppression in microcontacts and contact resistance quantisation and overall quantum coherence in mesoscopic and nanoscopic structures related to the emerging physics of quantum computation in the solid state environment

Program and Abstracts Igor O. Kulik, NATO Advanced Study Institute, 1999 [Quantum Phenomena in Mesoscopic Systems](#) B. Altshuler, A. Tagliacozzo, V. Tognetti, 2004-01-28 This book is a snapshot of the vision shared by outstanding scientists on the key theoretical and experimental issues in Mesoscopic Physics Quantum properties of electrons in solid state devices and transport in semiconducting and superconducting low dimensional systems are discussed as well as the basis of quantum computing entanglement noise decoherence and read out Each chapter collects the material presented at a Varenna School course of last year by leading experts in the field The reader gets a flavor how theorists and experimentalists are paving the way to the physical realization of solid state qubits the basic units of the new logic and memory elements for quantum processing He will be surprised in finding that mesoscopic solid state devices which were invented just yesterday think of the Single Electron Transistor or the Cooper Pair Box are currently used as charge sensing applications in the equipment of frontier research laboratories These devices contribute as probing systems to produce

evidence on still unsettled questions in topics like the metal insulator transition in disordered two dimensional systems quantum Hall conductance in heterostructures or Kondo conductance in quantum dots

Towards the Controllable Quantum States Hideaki Takayanagi, 2003 The realizations of physical systems whose quantum states can be directly manipulated have been pursued for experiments on fundamental problems in quantum mechanics and implementations of quantum information devices Micro fabricated superconducting systems and electronic spins are among the most promising candidates This book contains the newest and most advanced research reports on such materials called OC Mesoscopic Superconductivity OCO and OC Spintronics OCO The former includes superconductor semiconductor hybrid systems very small Josephson junctions and micron size SQUIDS The latter includes the control of spin transports in semiconductor heterostructures nano scale quantum dots and spin injections Superconductor ferromagnetic metal hybrid structures are covered by both of the topics The proceedings have been selected for coverage in OCo Index to Scientific Technical Proceedings ISTP CDROM version ISI Proceedings

Experimental Quantum Computation and Information F. de Martini, C. Monroe, 2003-02-12 This Fermi Summer School of Physics on Experimental Quantum Information and Computing represents a primer on one of the most intriguing and rapidly expanding new areas of physics In this part the interest in quantum information QI science is due to the discovery that a computer operating on quantum mechanical principles can solve certain important computational problems exponentially faster than any conceivable classical computer But this interest is also due to the interdisciplinary nature of the field the rapid growth is attributable in part to the stimulating confluence of researchers and ideas from physics chemistry mathematics information theory and computer science Physics plays a paramount role in QI science as we realize that computing is itself a physical process subject to physical laws The incredible growth of classical computers and information processors in the 20th century stems from Turing's notion that a computer is independent of the physical device actually being used be they relays vacuum tubes or semiconductor transistors As we strive to build useful quantum information processors into the 21st century we thus look for any physical system that obeys the laws of quantum mechanics from single photons and atoms to quantum superconducting devices These Fermi lectures take us on a journey through these and other promising current experimental candidates for QI processing spanning quantum optics and laser physics atomic and molecular physics physical chemistry and condensed matter physics While this broad coverage of experimental physics represents a challenge to the student such an appreciation of these fields will be critical in the future success of quantum technology Indeed the most exciting feature of QI science is that the technology ultimately leading to a quantum processor is likely presently unknown

Physics of Quantum Rings Vladimir M. Fomin, 2025-08-19 Excerpts from the recension on the 1st edition The book published by Vladimir M Fomin from Leibniz Institute for Solid State and Materials Research Dresden is an authoritative monograph that offers for readers a broad exhaustive overview about the current status of the Physics of Quantum Rings All chapters are accessible for readers with knowledge of physics and engineering sciences

within the advanced level studies The book explores in depth the physics of quantum interference phenomena like the Aharonov Bohm effect which are essential for Quantum Rings A good third of the book is dedicated to fabrication characterization and physical properties of such structures The fabrication includes such methods as self organized arrangement and crystal growth with molecular beam epitaxy as well as high resolution lithography The second third of the book represents the theory of Quantum Rings especially under the perspective of their materials and optical properties the Coulomb interaction and finally their mathematical modeling The last third of the book focuses on the Aharonov Bohm effect of excitons a very new effect which is manifested through the optical properties of Quantum Rings The unique benefit of collecting such different topics in one band consists in enabling a holistic understanding of Quantum Rings This approach is necessary to ensure a further development in this field On the one hand this is a deepening exploration On the other hand it is equally important for implementation of the gained understanding in applications for future devices Translated from German K Karrai Physik Journal 15 52 53 2016 Excerpts from the recension on the 2nd edition A Lorke Physik Journal 18 91 2019 The editor Vladimir Fomin and contributors show impressively in their book which has now been published in a second edition that the now traditional classification into 3 2 1 or 0 dimensional systems is not as comprehensive as it seems This is because in contrast to the above mentioned systems Quantum Rings in mathematical sense are not singly connected And already the question whether a Quantum Ring is a closed quantum wire or a quantum dot from which the interior is cut out demonstrates how diverse and novel is the physics offered by Quantum Rings Also in the new edition the numerous authors illuminate the topic from different perspectives from materials science aspects of the growth of Quantum Rings through their optical and electronic characterization to theoretical studies of exotic topologies such as M bius stripes The new division into four Sections topology driven effects fabrication and characterization optical Aharonov Bohm Effect theory succeeded It is gratifying that the newly added chapters deal with current developments and concern such topics as THz spectroscopy or 2D materials The book is certainly not an easy reading However for both advanced students and scientists who wish to delve in larger breadth and depth into the topic this collection of reviews offers an extensive material showing that also beyond a point a line and a plane there is still plenty of room in the bottom Translated from German A Lorke Physik Journal 18 91 2019

Macroscopic Quantum Coherence and Quantum Computing Dmitri V. Averin, Berardo Ruggiero, Paolo Silvestrini, 2012-12-06 This volume is an outgrowth of the Second International Workshop on Macroscopic Quantum Coherence and Computing held in Napoli Italy in June 2000 This workshop gathered a number of experts from the major Universities and Research Institutions of several countries The choice of the location which recognizes the role and the traditions of Naples in this field guaranteed the participants a stimulating atmosphere The aim of the workshop has been to report on the recent theoretical and experimental results on the macroscopic quantum coherence of macroscopic systems Particular attention was devoted to Josephson devices The correlation with other atomic and molecular systems exhibiting a

macroscopic quantum behaviour was also discussed. The seminars provided both historical overview and recent theoretical ground on the topic as well as information on new experimental results relative to the quantum computing area. The first workshop on this topic held in Napoli in 1998 has been ennobled by important reports on observations of Macroscopic Quantum Coherence in mesoscopic systems. The current workshop proposed among many stimulating results the first observations of Macroscopic Quantum Coherence between macroscopically distinct fluxoid states in rf SQUIDS 20 years after the Leggett's proposal to experimentally test the quantum behavior of macroscopic systems. Reports on observations of quantum behaviour in molecular and magnetic systems, small Josephson devices, quantum dots have also been particularly stimulating in view of the realization of several possible q bits. Compendium of Quantum Physics Daniel

Greenberger, Klaus Hentschel, Friedel Weinert, 2009-07-25. With contributions by leading quantum physicists, philosophers and historians, this comprehensive A to Z of quantum physics provides a lucid understanding of key concepts of quantum theory and experiment. It covers technical and interpretational aspects alike and includes both traditional and new concepts, making it an indispensable resource for concise up to date information about the many facets of quantum physics. **Fundamentals**

of Quantum Information Dieter Heiss, 2008-01-11. Quantum information science is a rapidly developing field that not only promises a revolution in computer sciences but also touches deeply the very foundations of quantum physics. This book consists of a set of lectures by leading experts in the field that bridges the gap between standard textbook material and the research literature, thus providing the necessary background for postgraduate students and non specialist researchers wishing to familiarize themselves with the subject thoroughly and at a high level. This volume is ideally suited as a course book for postgraduate students and lecturers will find in it a large choice of material for bringing their courses up to date.

Semiconductor Spintronics and Quantum Computation D.D. Awschalom, D. Loss, N. Samarth, 2013-04-17. The past few decades of research and development in solid state semiconductor physics and electronics have witnessed a rapid growth in the drive to exploit quantum mechanics in the design and function of semiconductor devices. This has been fueled for instance by the remarkable advances in our ability to fabricate nanostructures such as quantum wells, quantum wires and quantum dots. Despite this contemporary focus on semiconductor quantum devices, a principal quantum mechanical aspect of the electron, its spin, has to a large extent been ignored except in as much as tunnel mechanical degeneracy. In recent years however, a new paradigm of electronics based on the spin degree of freedom of the electron has begun to emerge. This field of semiconductor spintronics, spin transport electronics or spin based electronics places electron spin rather than charge at the very center of interest. The underlying basis for this new electronics is the intimate connection between the charge and spin degrees of freedom of the electron via the Pauli principle. A crucial implication of this relationship is that spin effects can often be accessed through the orbital properties of the electron in the solid state. Examples for this are optical measurements of the spin state based on the Faraday effect and spin dependent transport.

measurements such as giant magnetoresistance (GMR). In this manner information can be encoded in not only the electron's charge but also in its spin state, i.e. Supermaterials Rudi Cloots, M. Ausloos, Marek Pekala, Alan J. Hurd, Gilbert Vacquier, 2012-12-06. What is a supermaterial? A concise definition is by no means obvious but a clue can be obtained from the topics discussed here. In addition to superconductors the reader will encounter magnetic effects of many kinds including giant and even colossal ones, organic conductors, photoconductors and even 400 year old Japanese ceramics. Processing is a prominent pursuit in supermaterials research especially but not exclusively of the superconductors. The papers on characterisation and theory break new ground particularly in pursuit of new optoelectronic phenomena. The parade of new materials recently synthesised often containing four or more elements is surprising. But it is in its reporting of new applications that the book stands out from circuits to sensors supermaterials are making their impact on society. *Future Trends in Microelectronics* S. Luryi, Jimmy Xu, Alex Zaslavsky, 2012-12-06. Silicon technology has developed along virtually one single line reducing the minimal size of lithographic features. But has this taken us to the point of diminishing returns? Are we now at a turning point in the logical evolution of microelectronics? Some believe that the semiconductor microelectronics industry has matured the research game is over comparisons with the steel industry are being made. Others believe that qualitative progress in hardware technology will come roaring back based on innovative research. This debate spirited as it is is reflected in the pages of *Future Trends in Microelectronics* where such questions are discussed. What kind of research does the silicon industry need to continue its expansion? What is the technical limit to shrinking Si devices? Is there any economic sense in pursuing this limit? What are the most attractive applications of optoelectronic hybrid systems? Are there any green pastures beyond the traditional semiconductor technologies? Identifying the scenario for the future evolution of microelectronics will present a tremendous opportunity for constructive action today. **Complexity from Microscopic to Macroscopic Scales: Coherence and Large Deviations** A.T. Skjeltorp, Tamas Vicsek, 2012-12-06. Many mesoscopic systems display adaptive behaviour changes in some physical property that results from a small change in an internal or external driving force. There is a kind of progression in adaptive phenomena from quantum mesoscopics to complex evolved cooperative systems and large scale events like turbulence. The field of mesoscopic magnetism especially quantum coherence and quantum tunnelling in spin systems and the coupling between mesoscopic magnetism and mesoscopic transport is currently a very active area of solid state physics. Dephasing is an important concept in mesoscopic systems like these. A basic question is the limit at which quantum mechanics breaks down and what it can be replaced with. Another interesting crossover is that between complexity and large excursions or events with turbulence as a prototype example. The book also contains a discussion of finance. Qualitatively speaking turbulence and financial markets are apparently similar so our understanding of turbulence may be relevant to understanding price fluctuations. Energy Localisation and Transfer Thierry Dauxois, 2004. This book provides an introduction to localised excitations in spatially discrete systems from the

experimental numerical and mathematical points of view Also known as discrete breathers nonlinear lattice excitations and intrinsic localised modes these are spatially localised time periodic motions in networks of dynamical units Examples of such networks are molecular crystals biomolecules and arrays of Josephson superconducting junctions The book also addresses the formation of discrete breathers and their potential role in energy transfer in such systems **Bose-Einstein**

Condensates and Atom Lasers S. Martellucci, Arthur N. Chester, Alain Aspect, Massimo Inguscio, 2007-05-08 Proceedings of the International School of Quantum Electronics 27th course on Bose Einstein Condensates and Atom Lasers October 19 24 1999 Erice Italy Since the experimental demonstration of Bose Einstein Condensation in dilute atomic gases there has been an explosion of interest in the properties of this novel macroscopic quantum system The book covers the methods used to produce these new samples of coherent atoms their manipulation and the study of their properties Emphasis is given to the anticipated development of new types of sources which more and more resemble traditional types of lasers Because of recent new applications and increasing demand for lasers sensors and associated instrumentation the chapters also cover current developments in the basic techniques materials and applications in the field of the generation of coherent atoms *21st Century Nanoscience - A Handbook* Klaus D. Sattler, 2020-04-22 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 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 ninth volume in a ten volume set covers industrial applications 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 **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

Spintronics Tomasz Blachowicz, Andrea Ehrmann, 2024-10-07 Spintronics being a part of electronics is under intense development for about forty years and mainly concerns transport of electronics spin in low dimensional structures This field based on often difficult theoretical concepts of quantum physics has surprisingly strong and real technological and application consequences Thus spintronic solutions concern memory systems information processing devices and are used as sensors to detect variety of physical fields The early development of this field can be associated with the names of such scientists as E I Rashba A Fert P Gr nberg J Barna B Hillebrands G G ntherodt I K Schuller M Grimsditch A Hoffman P Vavassori and S Datta This list is absolutely not closed and might be easily extended however it results rather from scientific history and contacts with people who influenced the research carriers of the authors The authors give in this up dated 2nd edition an insight into this emerging field providing theoretical and experimental aspects of spintronics and guide readers from a basic understanding of fundamental processes to recent applications and future possibilities opened by ongoing research The textbook is suited for students and for interested scientists who were discouraged by the theoretical formalism only

Trends in Boson Research A. V. Ling, 2006 Bosons are particles which form totally symmetric composite quantum states As a result they obey Bose Einstein statistics The spin statistics theorem states that bosons have integer spin Bosons are also the only particles which can occupy the same state as another All elementary particles are either bosons or fermions Gauge bosons are elementary particles which act as the carriers of the fundamental forces such as the W vector bosons of the weak force the gluons of the strong force the photons of the electromagnetic force and the graviton of the gravitational force Particles composed of a number of other particles such as protons or nuclei can be either fermions or bosons depending on their total spin Hence many nuclei are in fact bosons While fermions obey the Pauli exclusion principle no more than one fermion can occupy a single quantum state there is no exclusion property for bosons which are free to and indeed other things being equal tend to crowd into the same quantum state This explains the spectrum of black body radiation and the operation of lasers the properties of superfluid helium 4 and the possibility of bosons to form Bose Einstein condensates a particular state of matter It is important to note that Bose Einstein condensation occurs only at ultralow temperature There is

nothing exotic about bosons otherwise At any reasonable temperatures both the boson and fermion particles behave as classical particles i.e. particle in a box and follow the Maxwell Boltzmann Statistics This new book includes leading research from around the world

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