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The Quantum Hall Effect *The Quantum Hall Effect* **Quantum Hall Effects** *The Fractional Quantum Hall Effect* **Quantum Hall Effect Quantum Hall Effect The Quantum Hall Effects** *Quantum Hall Effects* **Perspectives in Quantum Hall Effects The Quantum Hall Effect Fractional Quantum Hall Effects: New Developments Quantum Hall Effect Introduction to Quantum Hall Effect QUANTUM HALL EFFECTS RECENT TH** *The Butterfly in the Quantum World* The Quantum Hall Effect **Quantum Hall Effect** *A New Platform for Edge Mode Manipulations in the Quantum Hall Effect* Mesoscopic Quantum Hall Effect **Introduction to the Theory of the Integer Quantum Hall Effect The Quantum Hall Effect The Quantum Hall Effect Mass Term Effect on Fractional Quantum Hall States of Dirac Particles** *Quantum Hall Effects* **High Magnetic Fields in Semiconductor Physics III Quantum Hall Effects Theory of the Integer and Fractional Quantum Hall Effects** Electrons in Solids **Quantum Hall Effect in a Strongly Disordered System The Physics of the Two-Dimensional Electron Gas** *Composite Fermions* **Excitations in the Fractional Quantum Hall Effect** *Field Theories of Condensed Matter Physics* **Spin and Charge Ordering in the Quantum Hall Regime The Quantum Hall Effect Quantum Hall Effect in 2D Electron Gas Composite Fermions** New Platform for Edge Mode Manipulations in the Quantum Hall Effect **Quantum Computing for Computer Scientists High Magnetic Fields in Semiconductor Physics III**

Presenting the physics of the most challenging problems in condensed matter using the conceptual framework of quantum field theory, this book is of great interest to physicists in condensed matter and high energy and string theorists, as well as mathematicians. Revised and updated, this second edition features new chapters on the renormalization group, the Luttinger liquid, gauge theory, topological fluids, topological insulators and quantum entanglement. The book begins with the basic concepts and tools, developing them gradually to bring readers to the issues currently faced at the frontiers of research, such as topological phases of matter, quantum and classical critical phenomena, quantum Hall effects and superconductors. Other topics covered include one-dimensional strongly correlated systems, quantum ordered and disordered phases, topological structures in condensed matter and in field theory and fractional statistics. The transport of electric charge through most materials is well described in terms of their electronic band structure. The present book deals with two cases where the charge transport in a solid is not described by the simple band structure picture of the solid. These cases are related to the phenomena of the quantum Hall effect and superconductivity. Part I of this book deals with the quantum Hall effect, which is a consequence of the behavior of electrons in solids when they are constrained to move in two dimensions. Part II of the present volume describes the behavior of superconductors, where electrons are bound together in Cooper pairs and travel through a material without resistance. Butterfly in the Quantum World by Indu Satija, with contributions by Douglas Hofstadter, is the first book ever to tell the story of the "Hofstadter butterfly", a beautiful and fascinating graph lying at the heart of the quantum theory of matter. The butterfly came out of a simple-sounding question: What happens if you immerse a crystal in a magnetic field? What energies can the electrons take on? From 1930 onwards, physicists struggled to answer this question, until 1974, when graduate student Douglas Hofstadter discovered that the answer was a graph consisting of nothing but copies of itself nested down infinitely many times. This wild mathematical object caught the physics world totally by surprise, and it continues to mesmerize physicists and mathematicians today. The butterfly plot is intimately related to many other important phenomena in number theory and physics, including Apollonian gaskets, the Foucault pendulum, quasicrystals, the quantum Hall effect, and many more. Its story reflects the magic, the mystery, and the simplicity of the laws of nature, and Indu Satija, in a wonderfully personal style, relates this story, enriching it with a vast number of lively historical anecdotes, many photographs, beautiful visual images, and even poems, making her book a great feast, for the eyes, for the mind and for the soul. The 1986 Advanced Study Institute on "The Physics of the two-Dimen sional Electron Gas" took place at the Conference Centre liTer Helme", close to Oostende (Belgium), from June 2 till 16, 1986. We were motivated to organize this Advanced Study Institute in view of the recent experimental and theoretical progress in the study of the two-dimensional electron gas. An additional motivation was our own theore tical interest in cyclotron resonance in two-dimensional electron systems at our institute. It is my pleasure to thank several instances and people who made this Advanced Study Institute possible. First of all, the sponsor of the Advanced Study Institute, the NATO Scientific Committee. Furthermore, the co sponsors: Agfa Gevaert, Bell Telephone Mfg. Co. N.V., Burroughs Belgium. Control Data. Digital Equipment Corporation, Esso Belgium. European Research Office (USA). Kredietbank. National Science Foundation (USA). Special thanks are due to the members of the Program Committee and the members of the Organizing Committee. I would also like to thank Mrs. H. Evans for typing assistance. The book presents a comprehensive yet concise introduction to the physics of two-dimensional electron systems in the quantum Hall regime, as well as an up-to-date overview of the current fields of research concerning the integer and fractional quantum Hall effect. The physics of two-dimensional electron systems at low temperatures and high magnetic fields are governed by the formation of discrete energy levels referred to as Landau levels. These narrow energy bands not only form the basis of the well-known quantum Hall effect but also promote strong interactions between the electrons, giving rise to some of the finest manifestations of many-body physics in solid state science. Examples include skyrmionic spin textures, ferromagnetic spin transitions, stripe and bubble phases, as well as fractional quantum Hall states with potential non-abelian exchange statistics. The thesis succeeds in profoundly deepening our understanding of these exotic states of matter, with a main focus on the density-modulated phases in the quantum Hall regime. These phases arise from the interplay of competing interactions and are characterized by a self-organized ordering of electrons in spatial patterns. Similar phases of matter are currently being studied in other material systems as well, most notably in high-temperature superconductors. The thesis stands out not only in terms of its contribution to improving readers' grasp of physics, but also in the diversity and novelty of the measurement techniques employed, which take advantage of the interaction between the electrons and the surrounding crystal lattice. Enthusiasm for research on the quantum Hall effect (QHE) is unbounded. The QHE is one of the most fascinating and beautiful phenomena in all branches of physics. Tremendous theoretical and experimental developments are still being made in this sphere. Composite bosons, composite fermions and anyons were among distinguishing ideas in the original edition. In the 2nd edition, fantastic phenomena associated with the interlayer phase coherence in the bilayer system were extensively described. The microscopic theory of the QHE was formulated based on the noncommutative geometry. Furthermore, the unconventional QHE in graphene was reviewed, where the electron dynamics can be treated as relativistic Dirac fermions and even the supersymmetric quantum mechanics plays a key role. In this 3rd edition, all chapters are carefully reexamined and updated. A highlight is the new chapter on topological insulators. Indeed, the concept of topological insulator stems from the QHE. Other new topics are recent prominent experimental discoveries in the QHE, provided by the experimentalists themselves in Part V. This new edition presents an instructive and comprehensive overview of the QHE. It is also suitable for an introduction to quantum field theory with vividly described applications. Only knowledge of quantum mechanics is assumed. This book is ideal for students and researchers in condensed matter physics, particle physics, theoretical physics and mathematical physics. analyze the Hall effect in the plateau region relative to the fundamental value 2 h/e i expected in the simple one-electron picture for integer filling factors of Landau levels. Subsequent work in my laboratory in Wiirzburg using a super conducting solenoid confirmed the constancy of the Hall resistance both in Dorda's samples and in samples supplied by M. Pepper of the Cavendish Laboratory. With technical assistance from the Physikalisch-Technische Bundesanstalt in Braunschweig, an absolute measurement of the Hall resistance confirmed the 2 fundamental quantization relation RIJ = h/ei to an accuracy of about 1 part in]05. Recalling the practical applications of the Josephson effect, my initial thinking was oriented toward the idea of a resistance standard, but various groups at national laboratories which are involved in high precision measurements of fun damental constants pointed out that, in addition, the quantized Hall resistance yields a new fundamental measure of the fine structure constant Ci. These then were the initial events which led to the remarkable surge of interest within both the metrology and condensed matter physics communities in quantum transport in inversion layer systems. Subsequent developments have been many and varied and are described in detail in this volume. Enthusiasm for research on the quantum Hall effect (QHE) is unbounded. The QHE is one of the most fascinating and beautiful phenomena in all branches of physics. Tremendous theoretical and experimental developments are still being made in this sphere. 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It is also suitable for an introduction to quantum field theory with vividly described applications. Only knowledge of quantum mechanics is assumed. This book is ideal for students and researchers in condensed matter physics, particle physics, theoretical physics and mathematical physics. After a foreword by Klaus von Klitzing, the first chapters of this book discuss the prehistory and the theoretical basis as well as the implications of the discovery of the Quantum Hall effect on superconductivity, superfluidity, and metrology, including experimentation. The second half of this volume is concerned with the theory of and experiments on the many body problem posed by fractional effect. Specific unsolved problems are mentioned throughout the book and a summary is made in the final chapter. The quantum Hall effect was discovered on about the hundredth anniversary of Hall's original work, and the finding was announced in 1980 by von Klitzing, Dorda and Pepper. Klaus von KIitzing was awarded the 1985 Nobel prize in physics for this discovery. Page ix-xviii color illustrations : ix Quantum Hall effect; x skyrmions; xi edge states; xii bilayer QH system; xii pseudospins; xiv compound and charge-transferable states (theory); xv compound and charge-transferable states (experiments); xvi bilayer QH states at v = 1; bilayer QH states at v = 2; xviii skyrmions in bilayer QH states The experimental discovery of the fractional quantum Hall effect (FQHE) at the end of 1981 by Tsui, Stormer and Gossard was absolutely unexpected since, at this time, no theoretical work existed that could predict new struc tures in the magnetotransport coefficients under conditions representing the extreme quantum limit. It is more than thirty years since investigations of bulk semiconductors in very strong magnetic fields were begun. Under these conditions, only the lowest Landau level is occupied and the theory predicted a monotonic variation of the resistivity with increasing magnetic field, depending sensitively on the scattering mechanism. However, the ex perimental data could not be analyzed accurately since magnetic freeze-out effects and the transitions from a degenerate to a nondegenerate system complicated the interpretation of the data. For a two-dimensional electron the positive background charge is well separated from the two gas, where dimensional system, magnetic freeze-out effects are barely visible and an analysis of the data in the extreme quantum limit seems to be easier. First measurements in this magnetic field region on silicon field-effect transistors were not successful because the disorder in these devices was so large that all electrons in the lowest Landau level were localized. Consequently, models of a spin glass and finally of a Wigner solid were developed and much effort was put into developing the technology for improving the quality of semi conductor materials and devices, especially in the field of two-dimensional electron systems. The Poincaré Seminar is held twice a year at the Institut Henri Poincaré in Paris. The goal of this seminar is to provide up-to-date information about general topics of great interest in physics. Both the theoretical and experimental results are covered, with some historical background. Particular care is devoted to the pedagogical nature of the presentation. This volume is devoted to the quantum Hall effect. After a historical and general presentation by Nobel prize winner Klaus von Klitzing, discoverer of this effect, the volume proceeds with reviews on the mathematics and physics of both the integer and fractional case. It includes up to date presentations of the tunneling and metrology experiments related to the quantum Hall effect. It will serve the community of physicists and mathematicians at professional or graduate student level. One of the most exciting recent developments to have emerged from the quantum Hall effect is the subject of composite fermions. This important volume gives a self-contained, comprehensive description of the subject, including fundamentals, more advanced theoretical work, and results from experimental observations of composite fermions. Contents: Composite Fermions: Particles of the Lowest Landau Level (J K Jain & R K Kamilla)The Chern-Simons Fermi Liquid Description of Fractional Quantum Hall States (S H Simon)Fermionic Chern-Simons Field Theory for the Fractional Quantum Hall Effect (A Lopez & E Fradkin)Field Theory of the Fractional Quantum Hall Effect (G Murthy & R Shankar)Composite-Fermion Approach to the Edge State Transport (G Kirczenow & B L Johnson)Composite Fermions — Experimental Findings (R L Willett)Ballistic Transport of Composite Fermions in Semiconductor Nanostructures (J H Smet) Readership: Students and researchers in physics. Keywords:Composite Fermion;Quantum Hall Effect;Fractional Quantum Hall Effect;Laughlin State;Chern-Simons Fermions;Chern-Simons Theory;Flux Attachment;Landau Levels High magnetic fields have, for a long time, been an important tool in the investigation of the electronic structure of semiconductors. In recent yearsstudies of heterostructures and superlattices have predominated, and this emphasis is reflected in these proceedings. The contributions concentrate on experiments using transport and optical methods, but recent theoretical developments are also covered. Special attention is paid to the quantum Hall effect, including the problem of edge currents, the influence of contacts, and Wigner condensation in the fractional quantum Hall effect regime. The 27 invited contributions by renowned expertsprovide an excellent survey of the field that is complemented by numerous contributed papers. The quantum Hall effect (QHE) is one of the most fascinating and beautiful phenomena in all branches of physics. Tremendous theoretical and experimental developments are still being made in this sphere. In the original edition of this book, composite bosons, composite fermions and fractional charged excitations (anyons) were among the distinguished ideas presented. This new edition includes many novel ideas according to recent progress. Fantastic phenomena associated with the interlayer phase coherence and SU(4) quantum Hall ferromagnets in the bilayer system are extensively reviewed. The microscopic theory of the QHE is formulated based on noncommutative geometry, the underlying mathematical structure. Quasiparticles are described as noncommutative solitons. The coverage also includes the recent development of the unconventional QHE in graphene (a single atomic layer graphite), where the electron dynamics can be treated as relativistic Dirac fermions and even the supersymmetric quantum mechanics plays a key role. An instructive and comprehensive overview of the QHE, this book is also suitable as an introduction to quantum field theory with vivid applications. Only a knowledge of quantum mechanics is assumed. In recent years, remarkable progress in the fabrication of novel mesoscopic devices has produced a revival of interest in quantum Hall physics. New types of measurements, more precise and efficient than ever, have made it possible to focus closely on the electronic properties of quantum Hall edge states. This is achieved by applying charge and heat currents at mesoscopic length scales, attaching metallic gates and Ohmic contacts, and splitting edge channels with the help of quantum point contacts. The experiments reveal fascinating new phenomena, such as the interference, statistics, and topological phase shifts of fractionally charged quasi-particles, strong interaction and correlation effects, and phase transitions induced by non-Gaussian fluctuations. The thesis discusses some puzzling results of these experiments and presents a coherent picture of mesoscopic effects in quantum Hall systems, which accounts for integer and fractional filling factors and ranges from microscopic theory to effective models, and covers both equilibrium and non-equilibrium phenomena. This book is a compilation of major reprint articles on one of the most intriguing phenomena in modern physics: the quantum Hall effect. Together with a detailed introduction by the editor, this volume serves as a stimulating and valuable reference for students and research workers in condensed matter physics and for those with a particle physics background. The papers have been chosen with the intention of emphasizing the topological aspects of the quantum Hall effect and its connections with other branches of theoretical physics, such as topological quantum field theories and string theory. The contents include sections on integer effect, fractional effect, effect of global topology, effective theories, edge states and non-Abelian statistics. The experimental discovery of the fractional quantum Hall effect (FQHE) at the end of 1981 by Tsui, Stormer and Gossard was absolutely unexpected since, at this time, no theoretical work existed that could predict new struc tures in the magnetotransport coefficients under conditions representing the extreme quantum limit. It is more than thirty years since investigations of bulk semiconductors in very strong magnetic fields were begun. Under these conditions, only the lowest Landau level is occupied and the theory predicted a monotonic variation of the resistivity with increasing magnetic field, depending sensitively on the scattering mechanism. However, the ex perimental data could not be analyzed accurately since magnetic freeze-out effects and the transitions from a degenerate to a nondegenerate system complicated the interpretation of the data. For a two-dimensional electron gas, where the positive background charge is well separated from the two dimensional system, magnetic freeze-out effects are barely visible and an analysis of the data in the extreme quantum limit seems to be easier. First measurements in this magnetic field region on silicon field-effect transistors were not successful because the disorder in these devices was so large that all electrons in the lowest Landau level were localized. Consequently, models of a spin glass and finally of a Wigner solid were developed and much effort was put into developing the technology for improving the quality of semi conductor materials and devices, especially in the field of two-dimensional electron systems. The multidisciplinary field of quantum computing strives to exploit some of the uncanny aspects of quantum mechanics to expand our computational horizons. Quantum Computing for Computer Scientists takes readers on a tour of this fascinating area of cutting-edge research. Written in an accessible yet rigorous fashion, this book employs ideas and techniques familiar to every student of computer science. The reader is not expected to have any advanced mathematics or physics background. After presenting the necessary prerequisites, the material is organized to look at different aspects of quantum computing from the specific standpoint of computer science. There are chapters on computer architecture, algorithms, programming languages, theoretical computer science, cryptography, information theory, and hardware. The text has step-by-step examples, more than two hundred exercises with solutions, and programming drills that bring the ideas of quantum computing alive for today's computer science students and researchers. In this book we analyze the modern state of the problem connected with quantum Hall effect (integral and fractional). The quantum Hall effect is a quantum-mechanical version of the Hall effect, observed in two dimensional electron systems subjected to low temperatures (> 1K) and strong magnetic fields (10T), in which the Hall conductance takes on the quantized values (e2/h) with an integer (integer quantized Hall effect) or a rational fraction (fractional quantized Hall effect), independent of the detail of the sample geometry. The fractional quantum Hall effect is not complectly understood at the time being. Recently the idea of chiral heat transport in quantum Hall regime was pushed forward [33], we also analyze thermal transport in the fractional quantum Hall effect (FQHE). And we consider the problem of two electrons in a uniform magnetic field with the account of the center mass: (1) Quantum Mechanical Description and (2) Classical Description. This book explains the calculations of Laughlin and Schrieffer and shows how they are modified when the magnetic length is treated properly. The attachment of flux quanta to the electron has been discussed at length and experimental reports are re-examined in the light of variable magnetic length. The angular momentum theory of the Quantum Hall Effect explains the experimental data as is well based on theoretical grounds. An effort is made to compromise the flux-attached electron theory with the angular momentum theory which shows that some of the composite fermions become bosons. The Quantum Hall effect is explained on the basis of angular momentum theory. The importance of the negative spin has been discussed. The considerable amount of literature is reviewed. This book was first published in 2007. When electrons are confined to two dimensions, cooled to near absolute zero temperature, and subjected to a strong magnetic field, they form an exotic new collective state of matter. Investigations into this began with the observations of integral and fractional quantum Hall effects, which are among the most important discoveries in condensed matter physics. The fractional quantum Hall effect and a stream of other unexpected findings are explained by a new class of particles: composite fermions. This textbook is a self-contained, pedagogical introduction to the physics and experimental manifestations of composite fermions. Ideal for graduate students and academic researchers, it contains numerous exercises to reinforce the concepts presented. The topics covered include the integral and fractional quantum Hall effects, the composite-fermion Fermi sea, various kinds of excitations, the role of spin, edge state transport, electron solid, bilayer physics, fractional braiding statistics and fractional local charge. The discovery of the quantized and fractional Quantum Hall Effect phenomena is among the most important physics findings in the latter half of this century. The precise quantization of the electrical resistance involved in the quantized Hall effect phenomena has led to the new definition of the resistance standard and has metrologically affected all of science and technology. This resource consists of contributions from the top researchers in the field who present recent experimental and theoretical developments. Each chapter is self-contained and includes its own set of references guiding readers to original papers and further reading on the topic. In the last several decades, the quantum Hall effect has provided a remarkable platform for manipulating one-dimensional electronic modes and investigating fundamental physical phenomena. However, certain limitations make it difficult for various kinds of interesting modes structures to be formed using this platform. One example is the so called helical mode structure, in which two one-dimensional, counter propagating modes have opposite spins and thus spin and momentum are locked. Such helical modes have lately attracted significant interest, since, when coupled to a conventional superconductor, they are expected to manifest topological superconductivity and host Majorana zero modes. Even more interesting are fractional helical modes, which open the way for realizing generalized parafermionic zero modes. Possessing non-abelian exchange statistics, these quasiparticles may serve as building blocks in topological quantum computing. Here we present a new platform for manipulating integer and fractional quantum Hall edge modes, which allows the formation of robust one-dimensional helical as well as fractional helical modes. The platform is based on a carefully designed double-quantum-well structure in a GaAs based system hosting two electronic sub-bands in the quantum Hall effect regime. By electrostatic gating of different areas of the structure, counter-propagating integer, as well as fractional, edge modes with opposite spins are formed and their spin protection is verified. Beyond the formation of helical modes, the new platform can serve as a rich playground for new research. Some new possibilities include the artificial induction of compounded fractional edge modes and the construction of new edge mode-based interferometers. A pedagogical and self-contained discussion on monolayer and bilayer quantum Hall systems is given in this volume in a field-theoretical framework, with an introduction to quantum field theory, anyon physics and Chem-Simons gauge theory. This book aims to describe the physics of the integer and fractional quantum Hall effects (QHE) from a theoretical side. In the classical Hall effect, the Hall resistance is proportional to the applied magnetic field strength and varies continuously. So, the discovery of a stepwise change of the Hall resistance by von Klitzing in an ultra-thin layer of a MOSFET was a big surprise. The QHE is a macroscopic phenomenon and shows the exact quantum structure, which is one of the most fundamental phenomena in physics. The fractional quantum Hall effect has been explained assuming quasi-particles with fractional charges or Jain's composite fermions, the existence of which has not been verified experimentally. The author has been developing a theory based on a standard treatment of an interacting electron system without assuming any quasi-particle. This book will be easily understood by undergraduate students in physics. Knowledge of quantum field theory is needed to study Chapter 9. This book has been conceived as a multipurpose introduction and comprises three parts that can be viewed as independent units. The reader can start at any level. The first part (chapters 2, 3, A) is intended to convey physical insight into the subject. The next part (chapters 4-8) presents linear response theory as a basic tool and gives various applications of the theory. The final part (chapters 9-12) develops modern aspects such as "localization transition as a critical phenomenon" and the methods of "finite size scaling" and "multifractal analysis". Experimental and theoretical physicists graduate students as well as experts in transport theory will discover new aspects and interesting perspectives on magneto-transport. This book presents the high-precision analysis of ground states and low-energy excitations in fractional quantum Hall states formed by Dirac electrons, which have attracted a great deal of attention. In particular the author focuses on the physics of fractional quantum Hall states in graphene on a hexagonal boron nitride substrate, which was recently implemented in experiments. The numerical approach employed in the book, which uses an exact numerical diagonalization of an effective model Hamiltonian on a Haldane’s sphere based on pseudopotential representation of electron interaction, provides a better understanding of the recent experiments. The book reviews various aspects of quantum Hall effect: a brief history, recent experiments with graphene, and fundamental theories on integer and fractional Hall effects. It allows readers to quickly grasp the physics of quantum Hall states of Dirac fermions, and to catch up on latest research on the quantum Hall effect in graphene. High magnetic fields have, for a long time, been an important tool in the investigation of the electronic structure of semiconductors. In recent yearsstudies of heterostructures and superlattices have predominated, and this emphasis is reflected in these proceedings. The contributions concentrate on experiments using transport and optical methods, but recent theoretical developments are also covered. Special attention is paid to the quantum Hall effect, including the problem of edge currents, the influence of contacts, and Wigner condensation in the fractional quantum Hall effect regime. The 27 invited contributions by renowned expertsprovide an excellent survey of the field that is complemented by numerous contributed papers. The fractional quantum Hall effect has been one of the most active areas of research in quantum condensed matter physics for nearly four decades, serving as a paradigm for unexpected and exotic emergent behavior arising from interactions. This book, featuring a collection of articles written by experts and a Foreword by Klaus von Klitzing, the discoverer of quantum Hall effect and winner of 1985 Nobel Prize in physics, aims to provide a coherent account of the exciting new developments and the current status of the field. In the last several decades, the quantum Hall effect has provided a remarkable platform for manipulating one-dimensional electronic modes and investigating fundamental physical phenomena. However, certain limitations make it difficult for various kinds of interesting modes structures to be formed using this platform. One example is the so called helical mode structure, in which two one-dimensional, counter propagating modes have opposite spins and thus spin and momentum are locked. Such helical modes have lately attracted significant interest, since, when coupled to a conventional superconductor, they are expected to manifest topological superconductivity and host Majorana zero modes. Even more interesting are fractional helical modes, which open the way for realizing generalized parafermionic zero modes. Possessing non-abelian exchange statistics, these quasiparticles may serve as building blocks in topological quantum computing. Here we present a new platform for manipulating integer and fractional quantum Hall edge modes, which allows the formation of robust one-dimensional helical as well as fractional helical modes. The platform is based on a carefully designed double-quantum-well structure in a GaAs based system hosting two electronic sub-bands in the quantum Hall effect regime. By electrostatic gating of different areas of the structure, counter-propagating integer, as well as fractional, edge modes with opposite spins are formed and their spin protection is verified. Beyond the formation of helical modes, the new platform can serve as a rich playground for new research. Some new possibilities include the artificial induction of compounded fractional edge modes and the construction of new edge mode-based interferometers. The fractional quantum Hall effect has opened up a new paradigm in the study of strongly correlated electrons and it has been shown that new concepts, such as fractional statistics, anyon, chiral Luttinger liquid and composite particles, are realized in two-dimensional electron systems. This book explains the quantum Hall effects together with these new concepts starting from elementary quantum mechanics. NMR in quantum Hall effect is described and electronic polarization at half-filled Landau levels is given. Important appendices are provided."--BOOK JACKET.