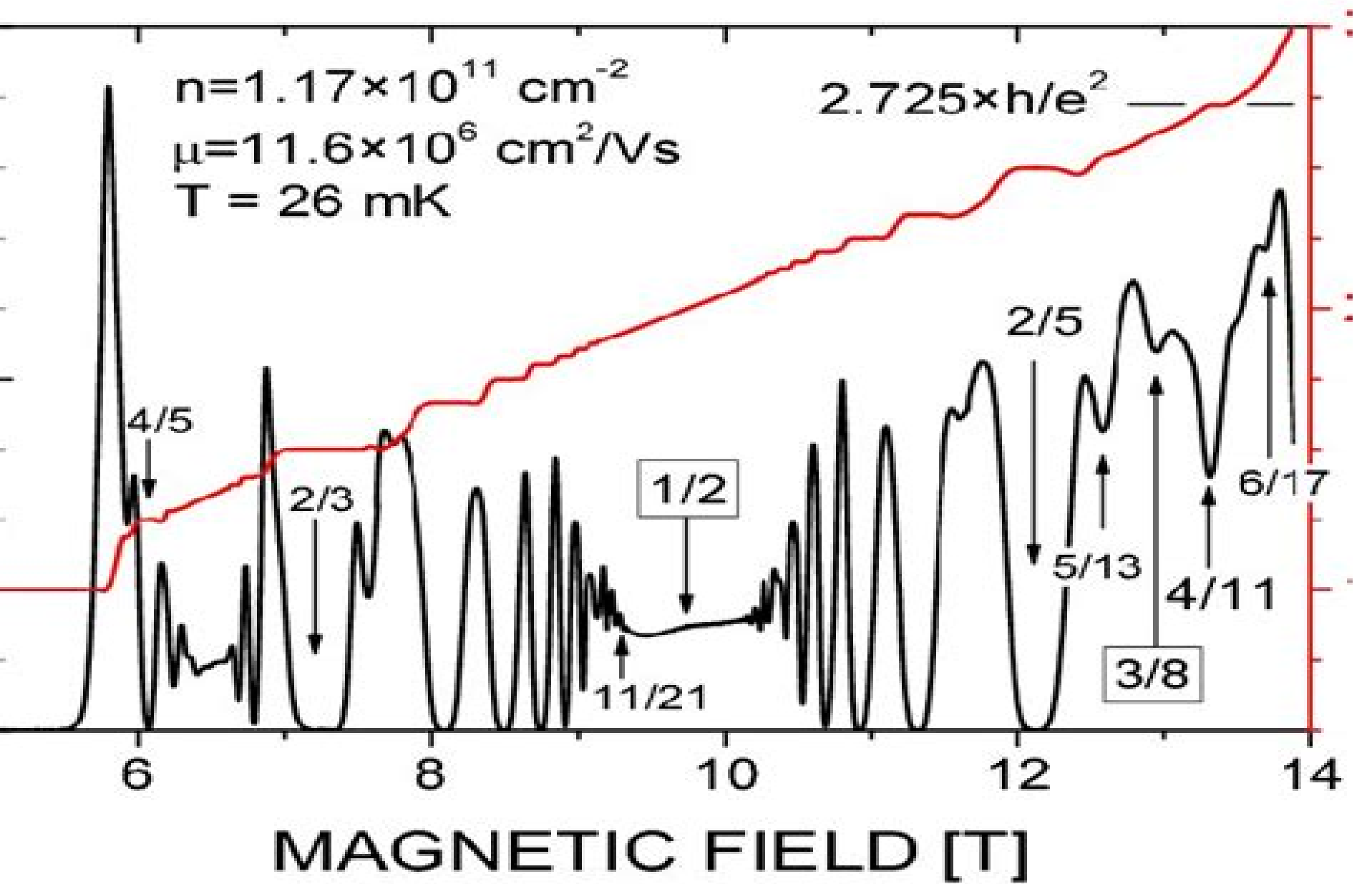


spins interact with the electrons' orbit and angular momentum in the presence of an incident current. These will be further



# Fractional Quantum Hall Effect

**JR Anderson**



## **Fractional Quantum Hall Effect:**

**The Fractional Quantum Hall Effect** Tapash Chakraborty, Pekka Pietiläinen, 2012-12-06 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 structures 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 experimental 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 semiconductor materials and devices especially in the field of two dimensional electron systems Fractional Quantum Hall Effects: New Developments

Bertrand I Halperin, Jainendra K Jain, 2020-06-09 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 **The Fractional Quantum Hall**

**Effect** Gregory Scott Boebinger, 1986 **The Quantum Hall Effects** Tapash Chakraborty, Pekka Pietiläinen, 1995-07-12

*Quantum Hall Effect* Michael Stone, 1992 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 THEORETICAL STUDY OF FRACTIONAL QUANTUM HALL EFFECT UNDER REALISTIC CONDITIONS. Tongzhou Zhao, 2022 The fractional quantum Hall effect FQHE arises when electrons near zero temperature confined in a 2D plane are subjected to a strong perpendicular magnetic field Since its first discovery 1 the

FQHE has always been one of the most important topics in condensed matter physics. The origin of the FQHE can be understood by the composite fermion (CF) theory according to which emergent particles called composite fermions are formed when an even number of vortices are attached to each electron. Because the vortices partially cancel the Aharonov-Bohm phase generated by the external magnetic field, CFs experience a reduced effective magnetic field in which Landau level-like energy bands called the  $\lambda$  levels are formed and filled by CFs at an integer filling. The FQHE of electrons of filling factor  $\nu = 2p/(2p+1)$  is therefore mapped into the integer quantum Hall effect (IQHE) of CFs. The CF theory successfully predicts many properties of the FQHE such as filling fractions, collective excitations, spin structures, emergent Fermi sea of CFs with well-defined Fermi wave vectors, and many more. While many great achievements have been made, lots of questions remain to be answered. For example, a typical simplification in FQHE problems is that the electron system is treated as a strict 2D system. While this approximation has been proved to be useful in many cases, it turns out that there are exceptions. In experiments, electrons are usually confined within finite quantum wells. The finite width modifies the effective interaction between electrons. It also changes the nature of the ground state by including the new degree of freedom as the finite well allows the mixing between different subbands. Another factor of importance is called the Landau level mixing, which is usually neglected in theoretical studies under the approximation that the magnetic field is strong enough to quench electrons to the lowest Landau level. However, under typical experimental conditions at present, the magnetic field is usually not that strong, and higher Landau level components are likely to mix into the system's ground state. The Landau level mixing brings a difference in the effective interaction between electrons and it also introduces the three-body interaction which breaks the particle-hole symmetry. The finite width effect and the Landau level mixing effect modify the effective interaction between electrons and may lead to new phases. For example, as the repulsion between electrons is reduced due to the finite width, it is possible that the vortices attached to electrons overscreen the repulsion and make the net interaction between composite fermions attractive. The attraction therefore can cause the pairing of composite fermions and lead to the so-called Moore-Read Pfaffian state or its particle-hole conjugation, the anti-Pfaffian state. To quantitatively describe the influence of the finite width and the Landau level mixing, we develop the three-dimensional fixed phase diffusion Monte Carlo method. This method takes care of the finite width effect and the Landau level mixing effect in a single framework and it is not a perturbative method which makes it suitable for studying strongly correlated systems. Equipped with the fixed phase diffusion Monte Carlo method, especially its 3D version, we systematically study several different systems in this thesis. We find that the finite width together with the Landau level mixing effect can lead to new phases as well as affect the systems' quantitative properties such as the transport gap. To be explicit, we find that the FQHE at filling factor  $1/2$  in finite GaAs quantum wells might be the Moore-Read Pfaffian state. We also find that the charge imbalance in such quantum wells does not favor the Moore-Read Pfaffian state. We find that the Bloch ferromagnetism of composite fermions observed in Ref. 2

might be induced by the change of the Landau level mixing we find that the Landau level mixing and the finite width cannot fully explain the discrepancy between the theoretical calculation and the experimental measurement of the transport gaps of the FQHEs in the sequence of  $n = 2n + 1$       **Theory of the Integer and Fractional Quantum Hall Effects** Shosuke

Sasaki, 2016 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      *The Integer and Fractional Quantum Hall Effect* Alan Usher, 1988      **The Quantum Hall**

**Effect** Richard E. Prange, Steven M. Girvin, 2012-12-06 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 Klitzing was awarded the 1985 Nobel prize in physics for this discovery      **Perspectives in Quantum Hall**

**Effects** Sankar Das Sarma, Aron Pinczuk, 2008-07-11 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      *Fractional Quantum Hall Effect in Wide Quantum Wells* Javad Shabani, 2011      *The Fractional Quantum Hall Effect in a Cavity* Lucas Winter, 2023

**Excitations in the Fractional Quantum Hall Effect** Pekka Pietiläinen, 1988      *Theory of Fractional Quantum Hall Effect* I. Z. Kostadinov, 1984      **Fractional Quantum Hall Effect in a Two-Dimensional Hole System** E. E. Mendez, W. I. Wang, L. L. Chang, L. Esaki, IBM THOMAS J WATSON RESEARCH CENTER YORKTOWN HEIGHTS NY., 1984      The Quantum Hall Effect Daijiro Yoshioka, 2014-01-15      *Topology and fractional quantum hall effect* Raimund Varnhagen, 1994

**Theory of the Integer and Fractional Quantum Hall Effects** Shōsuke Sasaki, 2016      **Field Theoretical Quantities in the Fractional Quantum Hall Effect** Stephanie Hythe Curnoe, 1997      **Understanding the Physics of a Possible Non-Abelian Fractional Quantum Hall Effect State**, 2010

We wish to present in this report experimental results from a one year Senior Council Tier 1 LDRD project that focused on understanding the physics of a possible non Abelian fractional quantum Hall effect state. We first give a general introduction to the quantum Hall effect and then present the experimental results on the edge state transport in a special fractional quantum Hall effect state at Landau level filling  $\nu = 5/2$ , a possible non Abelian quantum Hall state. This state has been at the center of current basic research due to its potential applications in fault resistant topological quantum computation. We will also describe the semiconductor Hall bar devices we used in this project. Electron physics in low dimensional systems has been one of the most exciting fields in condensed matter physics for many years. This is especially true of quantum Hall effect QHE physics which has seen its intellectual wealth applied in and has influenced many seemingly unrelated fields such as the black hole physics where a fractional QHE like phase has been identified. Two Nobel prizes have been awarded for discoveries of quantum Hall effects in 1985 to von Klitzing for the discovery of integer QHE and in 1998 to Tsui Stormer and Laughlin for the discovery of fractional QHE. Today QH physics remains one of the most vibrant research fields and many unexpected novel quantum states continue to be discovered and to surprise us such as utilizing an exotic non Abelian FQHE state at  $\nu = 5/2$  for fault resistant topological computation. Below we give a brief introduction of the quantum Hall physics.

The book delves into Fractional Quantum Hall Effect. Fractional Quantum Hall Effect is a crucial topic that needs to be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Fractional Quantum Hall Effect, encompassing both the fundamentals and more intricate discussions.

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    - Chapter 5: Conclusion
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  5. In chapter 4, the author will scrutinize the relevance of Fractional Quantum Hall Effect in specific contexts. The fourth chapter will explore how Fractional Quantum Hall Effect is applied in specialized fields, such as education, business, and technology.
  6. In chapter 5, the author will draw a conclusion about Fractional Quantum Hall Effect. The final chapter will summarize the key points that have been discussed throughout the book.
- The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Fractional Quantum Hall Effect.

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