The Fractional Quantum Hall Effect: Properties of an Incompressible Quantum Fluid

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ics Series, is most suitable for the latter audience. It could be used for part of a course on modern physics or for independent study. While physics majors would benefit from the broad survey Burge provides, they are likely to be left dissatisfied by the frequent casual references to new concepts with inadequate technical explanation. Burge provides references to original papers but not to supplementary pedagogical review articles. Most of the text is accessible to those with a basic knowledge of mechanics, electricity and magnetism. Knowledge of quantum mechanics is necessary to follow the discussions of the deuteron-bound state and barrier penetration.

A strength of Burge's text is its supply of good problems at the end of each chapter. Deficiencies include the characterization of quantum electrodynamics as "controversial" and the confusing brief treatment of gauge invariance.

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The Fractional Quantum Hall Effect: Properties of an Incompressible Quantum Fluid

T. Chakraborty and P. Pietiläinen
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The quantum Hall effect occurs when a two-dimensional electron gas becomes incompressible, provided that the density at which the incompressibility occurs is magnetic field dependent. For the integer quantum Hall effect, the incompressibility is easy to understand. The quantization of the electron's cyclotron motion means that only a discrete set of kinetic energies is allowed, and both the separation between allowed energies and the number of states of a given energy are proportional to magnetic field. (The set of states with a given kinetic energy is called a Landau level.) The incompressibility responsible for the integer QHE occurs at densities where an integer number of Landau levels are filled and the chemical potential jumps from one allowed kinetic energy to another.

The incompressibility responsible for the fractional QHE is due to electron–electron interactions. As the density is increased above certain fractional Landau-level fillings, it becomes impossible for electrons to avoid states of a lower relative angular momentum. Strengthened repulsive interactions cause the chemical potential to jump. At the critical filling factor there is only one many-body state in which the electrons can avoid the lower relative angular momentum. *The Fractional Quantum Hall Effect* by Tapash Chakraborty and Pekka Pietiläinen reviews the theory of these states and their elementary excitations.

Much is understood about the fractional quantum Hall effect. The incompressible states mentioned above have unique properties unlike any previously known. Their discovery has added to the small list of distinct classes of many-body systems. It is therefore not surprising that the ideas developed in trying to understand the fractional QHE are having an impact on other fields of theory, notably the theory of high-T_c superconductivity.

On the other hand, much remains to be understood about the fractional QHE. Many of the incompressible states arise in a much more subtle way than that outlined above, and little theory exists on the competition between disorder and interaction effects, despite interesting experimental results. It is important that fractional QHE theory be communicated to a broad audience both so that its notions can be applied elsewhere in physics and so that its own development will continue. That is the objective of this book.

The book succeeds especially strongly in providing the technical background necessary for those who wish to push the fractional QHE theory further ahead. The authors have gone to some trouble to make the book accessible to anyone with a solid background in statistical physics and quantum mechanics. They provide many details of derivations, omitted in the original references, and thus save many hours for those attempting to introduce themselves to the subject.

Emphasis is placed on explaining the properties of the elementary excitations of the incompressible states, including detailed accounts of their fractionally charged quasiparticles. Insights into the nature of these excitations have been achieved by the use of both small-system exact-diagonalization studies and trial wavefunctions that allow analogies to be made with classical two-dimensional plasmas. The authors describe both approaches with authority, having each made important contributions to the original research. A succinct appendix on the hypernetted-chain method, used for many of the technical calculations, adds to the completeness of the presentation and enhances the value of the book.

Readers seeking an impressionistic overview of fractional QHE theory and hoping for a lucid account of conceptual elements that they can take away and fit into another piece of nature's great puzzle are likely to be disappointed by this book. The book is intended for nonexpert researchers who want to begin investigating the fractional QHE. For these people, I believe that the book will prove invaluable and I strongly recommend it. The book can also serve as a useful reference for active researchers in either theory or experiment. I believe that this book will succeed in opening up the fractional QHE theory to a larger community. In writing it the authors have done a service to the subject, for there is much left to do.

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Multiphase Flow in Porous Media: Mechanics, Mathematics and Numerics

M. B. Allen, G. A. Behie and J. A. Trangenstein
Springer–Verlag, New York, 1988. $44.60 pb ISBN 0-387-96731-1

Fluid motion in porous media has been an area of great activity in recent years due to the combination of its practical importance in petroleum recovery, the scientific issues it raises in applied mathematics and numerical analysis, and the microscopic physics of disordered materials. This book, part of the Springer Lecture Notes in Engineering series, is primarily devoted to the second of these areas and gives an introduction to the mathematical problems of (hydrocarbon or water) reservoir simulation.

Multiphase Flow in Porous Media is based on three sets of lectures presented by the authors at the IBM Bergen Scientific Center, Bergen, Norway in 1986. Myron Allen discusses the basic mechanics of fluid flow in reservoirs, as formulated at the macroscopic level of continuum-averaged partial differential equations. Aside from surveying the essential introductory material on the subject, this lecture presents an extensive treatment of the thermodynamics of phase equilibrium for prob-