Preface

This book is addressed to all scientists interested in the use of high magnetic fields and in the use of high-field facilities around the world. In particular it will help young scientists and newcomers to the topic to gain a better understanding in areas such as condensed matter physics, in which the magnetic field plays a key role either as a parameter controlling the Hamiltonian, or as an experimental tool to probe the underlying mechanism. This concerns mostly strongly correlated and (or) low dimensional systems. Rather than covering all these subjects in detail, the philosophy here is to give essential physical concepts in some of the most active fields, which have been quickly growing in the last ten to twenty years. Besides its role as a physical parameter in condensed matter physics, a large magnetic field is essential to Electron Paramagentic Resonance (EPR) and Nuclear Magnetic Resonance (NMR) spectroscopies. The state of art of high resolution NMR in liquids and solids and high frequency EPR applied to fields like chemistry and biology are also reviewed in this volume.

The first series of chapters is devoted to the integer and the Fractional Quantum Hall Effects (FQHE) in two-dimensional electron systems. C. Glattli brushes an historical background and a comprehensive review of transport phenomena in these systems, including recent developments on the mesoscopic electronic transport at the edges of quantum Hall samples, chiral Luttinger liquids and fractional excitations. R. Shankar gives a deep introduction to the microscopic theories of FQHE. After a short review of most popular trial wavefunctions and their physical content, he focuses on the Hamitonian theory which is compared to other theoretical approaches and experiments. These two general lectures are followed by the chapter of I. Kukushkin, which reviews magneto-optics experiments on composite fermions, and the chapter of M. Fogler, which surveys the theoretical and experimental state of the art of, stripe, bubble and charge density phases recently discovered in two dimensional electron liquid when many Landau levels are occupied.

The next series of chapters are devoted to quantum magnetism. M. Rice gives a comprehensive review of spin-ladders, while C. Lhuillier emphasizes 2D frustrated magnets, which represent another class of magnets with spin liquid ground states. These theoretical lectures are followed by two experimental reviews: M. Horvatić explores the possibilities of NMR in the investigation of quantum antiferromagnets with carefully selected examples, while C. Broholm

gives an extensive review of neutron experiments probing quantum spin chains under high magnetic field.

The physics of quasi-one dimensional conductors is covered in the chapter of C. Bourbonnais, which introduces the properties of the one-dimensional electron gas, tackles the problem of interchain coupling and reviews the various instabilities of the system leading the formation of higher dimensionality states. This theoretical background is compared to experimental results in quasi-one dimensional organic and inorganic conductors. The experimental situation in quasi-one dimensional electronic systems is also developed in the chapter of D. Jérome, which is devoted to the family of the Bechgaard salts and to doped spin-ladders.

Quasi-1D organic conductors are famous for the rich physics they exhibit as a function of the magnetic field: Field Induced Spin Density waves, Lebed angles, dimensionality crossover. Unfortunately, these aspects are not covered in this book, but the reader is encouraged to consult dedicated monographs such as: P. Chaikin, J. Phys. I (France) **6**, 1875 (1996) and "Organic Superconductors "by T. Ishiguro, K. Yamaji and G. Saito, 2nd edition, (Springer Heidelberg, 1998).

The following two chapters are devoted to the problem of superconductivity in high magnetic fields, with the specific problem of reentrance in some low dimensional systems. The problem is treated from the theoretical point of view in the chapter of V. Mineev, and the experimental situation in low dimensional organic salts is reviewed by T. Ishiguro.

The discovery of high temperature superconductors has revitalized the physics of vortices in type II superconductors. This new physics of vortex matter, in which the magnetic field is an external adjustable parameter able to switch from liquid to solid or glassy states, is covered from both theoretical and experimental sides in the chapter written by T. Giamarchi and S. Batthacharya.

The two next chapters are devoted to three-dimensional magnetic systems. T. Kimura and Y. Tokura review the physical properties of manganites and related oxides, famous for their "colossal "magnetoresistance, including the magnetic field induced melting of charge/orbital- ordered state. Some of these manganites belong to the class of materials referred to as "half-metals", the properties of which are described in details in the lecture of J. Coey.

The last two chapters devoted to condensed matter physics bear on the effect of electron–electron interaction near the metal insulator transition, given by Zvi Ovadyahu, and the interference effects in disordered insulators by M. Sanquer. Both involve subtle magneto–transport experiments.

The last four chapters of the book are in a different spirit and describe different applications of resonance spectroscopy. J. Prestegard reviews the recent progress of high resolution NMR in liquids and their application to the determination of biological structures. D. Massiot describes the state of the art of high resolution solid-state NMR in high field, and the possibilities opened for structural studies of various organic and inorganic classes of compounds. D. Gatteschi describes the advantages of high frequency cw EPR, from single ions to integer spin of molecular clusters, whereas M. Fuchs and K. Möbius explore the

most recent developments of high field pulsed EPR and their applications to the structure and dynamics of proteins and bio-organic molecules.

The chapters of this book are based on lectures that were given at a two-week International School held in Cargèse, on the Corsica island, in the spring of 2001. It is a great pleasure for us to acknowledge the financial support of the European Community, under the frame of the High Field Infrastucture Cooperative Network, and that of the Centre National de la Recherche Scientifique. We also would like to express our gratitude to all the staff of the Cargèse center and of the GHMFL, who have been of great help in the success of this school, and we are sure that all participants will keep a good memory of the warm welcome of the Cargèse inhabitants. We trust that this book will help many other scientists to benefit from the excellent overviews presented at the International School and that it will contribute in a small way to further advancing this fascinating area of physics.

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