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The Large Hadron Collider: Harvest of Run 1

By Thomas Schöner-Sadenius (ed.)

Springer

On the verge of obtaining new results from the first year of Run 2 of the LHC, a book summarising the results from Run 1 is highly anticipated.

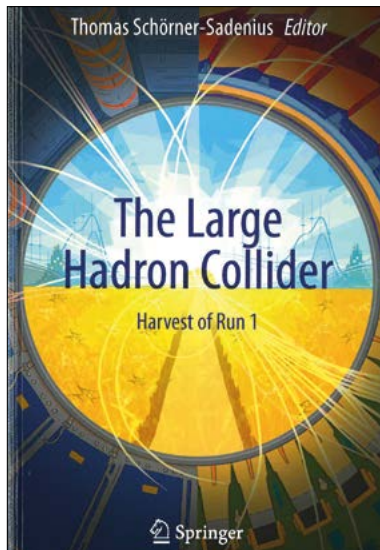
The impressive effort needed to write such an overview must be acknowledged. The LHC experiments (ALICE, ATLAS, CMS, LHCb, and TOTEM) have published more than 1000 results from Run 1, and producing a comprehensive review of them while ensuring that the book remains accessible to young researchers is a demanding task that requires careful editorial work. This seems to have been the intention of the authors, which in my opinion has been accomplished.

Individual chapters are written by teams of well-recognised experts working in each specific field. The book starts with a short historical overview, describing the development of the LHC project – three-decades long – from first ideas to its realisation. The reader will find an interesting summary of the difficult financial situation the LHC had to confront, while receiving harsh competition from similar accelerator projects (UNK, SSC).

Clearly, the legacy of Run 1 is marked by the discovery of the Higgs boson, therefore a long and interesting chapter is dedicated to a description of its discovery and, later on, to the measurement of its properties, but the volume shows the impact of the LHC results on all of the different fronts of high-energy physics. The interplay between recent theory developments and experimental results is clearly presented. Furthermore, each physics chapter is introduced by a short theoretical summary, showing the pedagogical intention of the authors. Results are often contextualised by comparing them with the current status of each topic and by showing perspectives for future improved results.

Besides allowing senior researchers to quickly scan through the plethora of LHC results, the book will be particularly useful for young researchers trying to familiarise themselves with certain aspects of LHC physics. It stimulates further reading and gives a long list of references at the end of each chapter – in my opinion, this is a main bonus of the book.

Although the results from Run 1 at the LHC are destined to be quickly outdated by new results from Run 2, I believe that this book could serve for several years as initial reading for any physicist when first confronted with



LHC physics, thanks to the historical and pedagogical point of view adopted.

• Paolo Meridiani, INFN Roma (Italy).

60 Years of CERN Experiments and Discoveries

By Herwig Schopper and Luigi Di Lella (eds.)

World Scientific

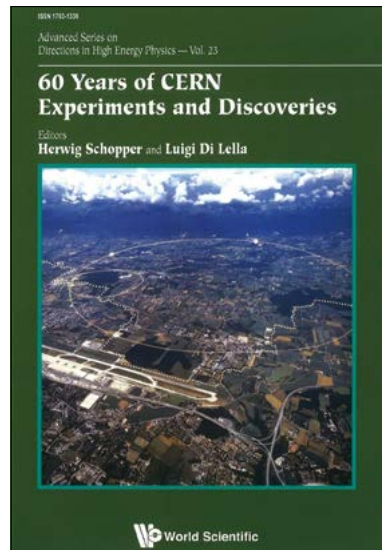
Also available at the CERN bookshop

This book is a treasure trove of particle physics, highly recommended for physics teachers, graduate students and professionals of the field. With 17 chapters, it offers a concise essay of 60 years of particle physics at CERN from the point of view of the people in charge of the different experiments.

The first three chapters cover the present day at CERN: the full LHC programme, from the Higgs boson discovery to Beauty physics and quark–gluon plasma. They draw a relatively synthetic but precise picture of the four major experiments at LHC (ATLAS, CMS, LHCb, ALICE), giving really useful information to the reader.

The surprises, at least for me, come in the chapters that follow. They explain physics that is already in textbooks, but provide a great deal of detail about each specific endeavour – a pleasure to read if you are interested not only in the results but also in the intellectual journey and historical context.

Chapters 4 (number of light neutrinos) and 5 (gauge-coupling-constants precision physics) are dedicated to LEP results,



chapter 6 to the discovery of W and Z bosons in the Super Proton Synchrotron (SPS), and chapter 7 to the fundamental neutral current experiment at Gargamelle. Going back in time to Gargamelle, one can appreciate the ingenuity of the physicists' community struggling with the data to get a clearer picture of electroweak physics, at a time when the microelectronics revolution was still far off.

From chapter 8 to the end of the book, the reader picks up little gems. CERN is not only the LHC or LEP, but much more. Chapter 8 tells the story of neutrino physics at the SPS, in particular the precise measurement of the Weinberg angle and how that effort paved the way for actual neutrino-oscillation experiments. Chapters 9 and 10 are dedicated to kaon physics, in particular to the direct measurement of CP violation in kaon decay by the NA31/NA28 collaborations at the SPS, and to discrete symmetry (T, CPT and CP) measurements in the neutral-kaon system using the LEAR antiproton storage ring. Here, the reader discovers that the large volume of statistics on $\pi\pi$ decays possible at LEAR (now evolved to LEIR) enabled testing of the equivalence principle between particles and antiparticles, as well as of EPR correlations.

Chapter 11 highlights the physics discoveries at the Intersecting Storage Rings (ISR). Remembered as the first hadron collider and a technological feat, it also made an important contribution



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to fundamental physics by discovering the rise of the proton–proton scattering total cross-section. Chapters 12 and 13 discuss topics out of chronological order. Chapter 13 concerns the discovery of partons in hadrons from the ISR to the SPS, with details of the hadron internal structure, revealed by muon scattering in the SPS, given in chapter 12. “Modern” LHC parlance as “gluon colliders” can be traced back to the ISR; jet production, now a workhorse at the LHC programme, was evident from the SPS UA2 experiment. Deep inelastic scattering has been an active field at CERN for more than 35 years, and has had a fundamental impact on the present day understanding of hadronic-matter structure.

But CERN is not only about colliders. Atomic physics is very much alive there, as well as the study of exotic atoms (pionic, muonic, kaonic) and anti-atoms. Chapter 14 traces the history of antimatter–exotic matter at CERN, up to present-day experiments at ALPHA and ATRAP, even for testing the equivalence principle (does antimatter fall down?) with AEGIS or GBAR.

Muon-storage technological challenges and the $g-2$ measurement at CERN, a hot topic today, come within chapter 15, which contains two special-relativity surprises: a gamma-ray time-of-flight experiment from the Proton Synchrotron (PS) target, demonstrating the independency of c from the source motion, and time dilation in circular orbits for the muon lifetime in flight. Chapter 16 explains the beginning of the accelerator programme at CERN with the physics contribution of the CERN 600 MeV Synchrocyclotron (pi meson decays), in particular the first measurement of the muon anomalous moment.

Closing the book, chapter 17 discusses part of the nuclear-physics programme, specifically with ISOLDE – an “alive and kicking” experiment dedicated to the study of radioactive nuclei, mainly nuclear ground-state properties and excited nuclear states populated in radioactive decays, but now also leading the production of medical isotopes for fundamental studies in cancer research.

As a final remark, I enjoyed this book not only for the range of topics and extensive explanations, but also because it is easily readable – not an easy goal when the number of authors is so high. Definitely a must read.

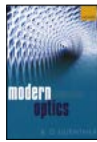
● *Rogelio Palomo, University of Sevilla (Spain).*

Books received

Modern Optics (2nd edition)

By B D Guenther

Oxford University Press



This book is the result of a one-semester course that has been taught by the author to juniors, seniors and first-year graduate students in physics and engineering at Duke

University for 13 years.

It gives an overview of the fundamentals in optical science, the principals of which are explained by using a rigorous approach based on Maxwell's equations. Besides the classical topics, the book includes some material not found in more conventional textbooks on the subject: nonlinear optics, guided waves, photonic structures, surface plasmons and more. Anisotropy is also largely discussed, even if it needs the use of tensors, because of its importance in modern optics.

This 2nd edition retains an emphasis on both the fundamental principles of optics and exposure to actual optical-engineering problems and solutions. It introduces a large number of applications such as laser optics, fiber optics and medical imaging, which makes the book appealing to engineering students and professors.

A selection of optional material has also been added in the appendices, adaptable to different interests and to stimulate further reading. Many pictures, tables and diagrams accompany the text, making the exposition clear and complete.

Instantons and Large N: An Introduction to Non-Perturbative Methods in Quantum Field Theory

By Marcos Mariño

Cambridge University Press



Intended to be a fundamental resource for graduate students in particle, theoretical and mathematical physics, the book gives a highly pedagogical introduction to some advanced topics of quantum field theory (QFT).

The standard approach to QFT, one of the pillars of modern physics, is the perturbative one. Although successful, it is not sufficient to address many important phenomena. In this book, the author gives an introduction to two methods that go beyond the standard perturbative framework: instantons and large- N expansion.

The first part of the volume offers a detailed exposition of instantons in quantum mechanics, supersymmetric quantum mechanics, the large-order behaviour of perturbation theory, and Yang–Mills theories. In the second part, large- N expansion in QFT is examined.

The topics are presented in a well-organised form, and each subject is explained with detailed mathematical

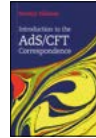
derivations and then illustrated with a model or example in which it is implemented. This enables students to move easily through the text and gain practical experience with the most important tools of the field.

Apart from the basic building blocks in the theory of instantons and of large- N expansion, the choice of topics has been dictated by the author's taste and expertise, as he himself admits. As a consequence, some subjects covered extensively elsewhere in the literature are left aside, while space has been given to topics not commonly treated in textbooks. Moreover, supersymmetry has been avoided as much as possible, by choice.

Introduction to the AdS/CFT Correspondence

By Horațiu Nastase

Cambridge University Press



The aim of this book is to give a pedagogical introduction to Anti-de Sitter/Conformal Field Theory, or AdS/CFT, which is the relation between quantum field theory with conformal invariance, living in our flat 4D space, and string theory, which is a quantum theory of gravity and other fields, living in the background solution of $AdS_5 \times S^5$ (5D anti-de Sitter space multiplied by a five-sphere).

Assuming knowledge of only the basics of quantum field theory, the text provides readers with all of the concepts and tools needed to engage with AdS/CFT. In the first part, the author describes some fundamental concepts of general relativity, supersymmetry, supergravity, string theory, conformal field theory and D-branes. He has chosen not to overload the text with too many details about these fields, to keep the reader focused. The second section provides a clear and rigorous dissertation on AdS/CFT correspondence (in the context of its best understood example). Finally, in the third part, more specialised applications are discussed, such as QCD, quark–gluon plasma and condensed matter.

The book is self-contained, introducing all of the necessary basic concepts and most of the AdS/CFT methods and tools, but for an in-depth or exhaustive treatment, the reader is advised to refer to research articles. The many examples and exercises at the end of each chapter reveal the pedagogical vocation of the volume, nevertheless it will also be a useful reference for researchers in the fields of particle, nuclear and condensed-matter physics.

Silver Nanoparticles: From Silver Halide Photography to Plasmonics

By Tadaaki Tani

Oxford University Press



This book gives a comprehensive review of the synthesis, optical properties and applications of silver nanoparticles and nanomaterials.

Today, nanoscience, which is the study of extremely small things, plays a fundamental role in technology, and is connected to many scientific fields: physics, chemistry, biology, material science and engineering. Nanoparticles are of great scientific interest because they provide a bridge between bulk materials and atomic or molecular structures. We know that bulk material normally has constant physical properties regardless of its size, whereas size-dependent properties are often observed at the nanoscale.

Researchers are interested in nanoparticles of noble metals, including silver (Ag), because they show high potential for possible future plasmonic devices. On the other hand, nanoparticles of silver and silver halides (AgX) have been extensively studied in silver-halide photography.

The author offers an overview of both the properties of silver nanoparticles and related materials, and know-how in AgX photography. The first part (chapters 1–3) introduces the structure and preparation of nanoparticles of Ag and other noble metals for plasmonics, as well as those of Ag and AgX nanoparticles in photography. Then, in chapter 4, the relevant properties and performance of nanoparticles of Ag and related materials are presented, focusing in particular on light absorption and scattering. In the third part (chapters 5–7), the author discusses the applications of this research in catalysis, photovoltaic effects and plasmonics. New ideas in the field are also presented at the end.

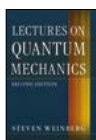
Full of pictures and references, this text represents a synthesis of up-to-date knowledge in the field.

Lectures on Quantum Mechanics (2nd edition)

By Steven Weinberg

Cambridge University Press

Also available at the CERN bookshop



After the great success of the 1st edition, the textbook on modern quantum mechanics by Nobel laureate Steven Weinberg is presented in a fully updated 2nd edition.

Thanks to his profound knowledge and expertise, the author explains in an exceptionally clear and rigorous way the topics of the subject that he considers to be the most important for a one-year graduate course. He begins with an historical review of quantum mechanics and an account of classic solutions to the Schrödinger equation, then goes on to develop quantum mechanics in a modern Hilbert-space approach.

Weinberg gives much greater emphasis than usual to principles of symmetry, and covers subjects that are often omitted in books on quantum mechanics, such as Bloch waves, time-reversal invariance, the Wigner–Eckart theorem, isotopic spin symmetry, Levinson's theorem, etc. This 2nd edition includes major additions to existing chapters and has also been enriched by the addition of six new sections, covering topics such as the rigid rotor and quantum-key distribution.

The author takes care to explain the formalism, to be clear and coherent, and includes numerous examples from elementary particle physics. Problems are also included at the end of each chapter. Well-structured and easily readable, this book is bound to receive the same approval as the 1st edition did.

The Standard Model of Quantum Physics in Clifford Algebra

By C Daviau and J Bertrand

World Scientific



In this book, the authors discuss the Standard Model, drawing upon Clifford algebra (a special case of geometric algebra) of space–time, following the work of Hestenes and other physicists that in the 1980s revisited Dirac theory using Clifford formalism.

After an introduction on the basics of Clifford algebra and the Dirac equation, the authors move on to place Dirac theory in a 3D framework, based on the Clifford algebra Cl_3 of 3D space. They introduce their homogeneous nonlinear equation and explain why, in their opinion, it is better than the Dirac equation, which is its linear approximation.

Several consequences deriving from these novelties are then discussed extensively. In particular, a first attempt to reconcile the quantum world with inertia and gravitation is made.

The book also includes three appendices, reporting demonstrations and calculations related to the concepts explained in the text, and a rich bibliography.

Classical Dynamics: A Modern Perspective (2nd edition)

By E C G Sudarshan and N Mukunda

World Scientific



More than 40 years since the appearance of the first edition, this book is now published in a revised version that is presented with the same passion and dedication as the

original. The authors confess that they have always had an “affair of the heart” with classical dynamics, and this remains alive.

In the volume, classical dynamics is treated as a subject in its own right, as well as a research frontier. While presenting all of the essential principles, the authors demonstrate that a number of key results originally considered only in the context of quantum theory and particle physics have their foundations in classical dynamics.

Even if the text is based on what the authors define as “our understanding of quantum mechanics”, this new version builds on many suggestions coming from other physicists and continuous dialogue with students using the book as a reference.

Key Nuclear Reaction Experiments: Discoveries and Consequences

By Hans Paetz gen. Schieck

IOIP Publishing



Nuclear physics has seen enormous developments in the last century. The study of nuclear reactions has given fundamental insights into the nature of the forces that act within nuclei and on the structure of nuclides.

This book traces the history of the development of nuclear physics by reviewing key experiments that have shaped our understanding of the field. It is interesting to look back to the beginning and discover how crucial results were obtained by very simple means, and how the sophisticated and complex experiments of today came about. Experiments are described in detail and their outcomes are discussed. In some cases, original drawings are included, accompanied by new figures and plots when needed.

The theoretical background to the experiments is also given, but is kept concise. Nevertheless, the reader can refer to the references at the end of each chapter for a more in-depth treatment of individual subjects.

Besides drawing on the history of experiments and related discoveries, the book shows how misinterpretations and prejudices in some cases prevented or delayed fundamental breakthroughs.