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Relativistic Quantum Mechanics: An Introduction to Relativistic Quantum Fields

By Luciano Maiani and Omar Benhar

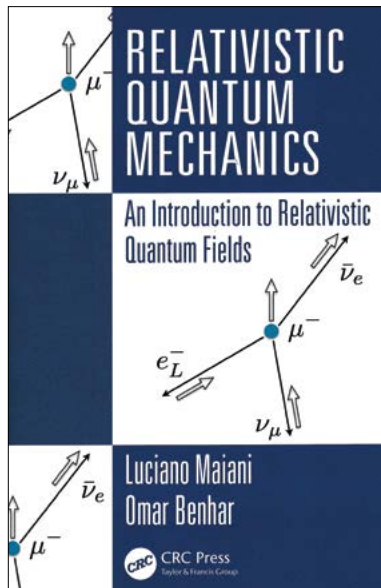
CRC Press

Quantum field theory (QFT) is the mathematical framework that forms the basis of our current understanding of the fundamental laws of nature. Its present formulation is the achievement of almost a century of theoretical efforts, first initiated by the necessity of reconciling quantum mechanics with special relativity. Its success is exemplified by the Standard Model, a specific QFT that spectacularly accounts for all of the observations performed so far in particle-physics experiments over many orders of magnitude in energy. Learning and mastering QFT is therefore essential for anyone who wants to understand how nature works on the smallest scales.

This book gives a concise and self-contained introduction to the basic concepts of QFT. As mentioned in the preface, it is mainly addressed to students with different interests who are approaching the subject for the first time, and is based on a series of lecture courses taught by the authors over the course of a decade at the University of Rome La Sapienza. Topics are selected and presented following their historical development and constant reference is made to those experiments that marked key advances, and sometimes breakthroughs, on the theoretical front. Some important subjects were not included, but they can be reconsidered later for more in-depth study.

The book is conceived as the first of a series that comprises two other texts on the more advanced topics of gauge theories and electroweak interactions (in collaboration with the late Nicola Cabibbo). The authors do not indulge in technical discussions of more formal aspects but try to derive the main physics results with the minimum amount of mathematical machinery. Although some concepts would have benefited from a more systematic discussion, such as the scattering matrix and its definition through asymptotic states, the goal of giving an essential introduction to QFT and providing a solid foundation in this for the reader is achieved overall. The experience of the authors as both proficient teachers of the subject and main players is crucial to finding a good balance in establishing the QFT framework.

The first part of the book (chapters 1–3) is dedicated to a short review of classical dynamics in the relativistic



limit. Starting from the principles of relativity and minimal action, the motion of point-like particles and the evolution of fields are described in their Lagrangian and Hamiltonian formulations. Special emphasis is given to symmetries and conservation laws. Quantisation is introduced in chapter 4 through the example of the scalar field by replacing the Poisson brackets with commutators of operators. Equal-time commutation rules are then used to define creation and destruction operators and the Fock space. Chapter 5 deals with the quantisation of the electromagnetic field. The approach is that of canonical formalism in the Coulomb gauge, but no mention is made of the complication due to the presence of constraints on fields. Chapters 6 and 7 are dedicated to the Dirac equation and the quantisation of the Dirac field. Besides introducing the usual machinery of spinors and gamma matrices, they include a detailed analysis of the relativistic hydrogen atom as well as concise though important discussions about Wigner's method of induced representations as applied to the Lorentz group, micro-causality and the relation between spin and statistics. The propagation of free fields is analysed in chapter 8, while the three chapters that follow introduce the reader to relativistic perturbation theory. Chapter 12 discusses discrete

symmetries (C, P and T) in QFT, gives a proof of the CPT theorem and illustrates its consequences. The last part of the book is dedicated to applications of QFT formalism to phenomenology. The authors give a detailed account of QED in chapter 14 by discussing a variety of physical processes. The reader is here introduced to the method of Feynman diagrams through explicit examples following a pragmatic approach. The following chapter deals with Fermi's theory of weak interactions, again making use of several explicit examples of physical processes. Finally, chapters 13 and 16 are devoted to the theory and phenomenology of neutrinos. In particular, the last section discusses neutrino oscillations (both in a vacuum and through matter) and presents a thorough analysis of current experimental results. There is also a useful set of exercises at the end of each chapter.

Both the pragmatic approach and choice of topics make this book particularly suited for readers who want a concise and self-contained introduction to QFT and its physical consequences. Students will find it a valuable companion in their journey into the subject, and expert practitioners will enjoy the various advanced arguments that are scattered throughout the chapters and not commonly found in other textbooks.

● Roberto Contino, *Scuola Normale Superiore of Pisa, Italy.*

Learning Scientific Programming With Python

By Christian Hill

Cambridge University Press

Science cannot be accomplished nowadays without the help of computers to produce, analyse, treat and visualise large experimental data sets. Scientists are called to code their programs using a programming language such as Python, which in recent times has become very popular among researchers in different scientific domains. It is a high-level language that is relatively easy to learn, rich in functionality and fairly compact. It includes many additional modules, in particular scientific and visualisation tools covering a vast area in numerical computation, which make it very handy for scientists and engineers.

In this book, the author covers basic programming concepts – such as numbers, variables, strings, lists, basic data structures, control flow, and functions. It also deals with advanced concepts and idioms of the Python language and of the tools that are

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presented, enabling readers to quickly gain proficiency. The most advanced topics and functionalities are clearly marked, so they can be skipped in the first reading.

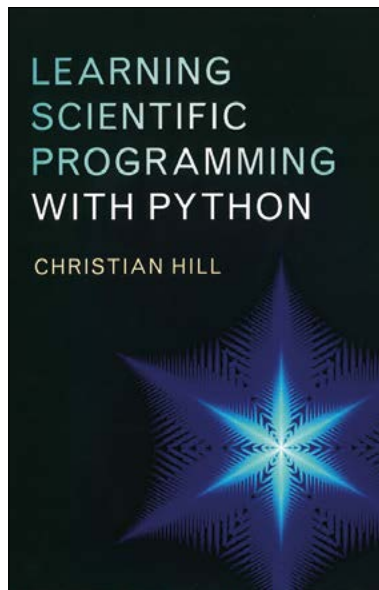
While discussing Python structures, the author explains the differences with respect to other languages, in particular C, which can be useful for readers migrating from these languages to Python. The book focuses on version 3 of Python, but when needed exposes the differences with version 2, which is still widely in use among the scientific community.

Once the basic concepts of the language are in place, the book passes to the NumPy, SciPy and Matplotlib libraries for numerical programming and data visualisation. These modules are open source, commonly used by scientists and easy to obtain and install. The functionality of each is well introduced with lots of examples, which is clearly an advantage with respect to the terse reference documentation of the modules that are available from the web. NumPy is the de facto standard for general scientific programming that deals very efficiently with data structures such as unidimensional arrays, while the SciPy library complements NumPy with more specific functionalities for scientific computing, including the evaluation of special functions frequently used in science and engineering, minimisation, integration, interpolation and equation solving.

Essential for any scientific work is the plotting of the data. This is achieved with the Matplotlib module, which is probably the most popular one that exists for Python. Many kinds of graphics are nicely introduced in the book, starting from the most basic ones, such as 1D plots, to fairly complex 3D and contour plots. The book also discusses the use of IPython notebooks to build rich-media documents, interleaving text and formulas with code and images into shareable documents for scientific analysis.

The book has many relevant examples, with their development traced from both science and engineering points of view. Each chapter concludes with a series of well-selected exercises, the complete step-by-step solutions of which are reported at the end of the volume. In addition, a nice collection of problems without solutions are also added to each section.

The book is a very complete reference of the major features of the Python language and of the most common scientific libraries. It is written in a clear, precise and didactical style that would appeal to those who, even if they are already familiar with the Python programming language, would like to develop their proficiency in numerical and



scientific programming with the standard tools of the Python system.

● Pere Mato Vila, CERN.

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Reviews of Accelerator Science and Technology: Volume 7

By Alexander W Chao and Weiren Chou (eds)

World Scientific

Also available at the CERN bookshop



Volume 7 of *Reviews of Accelerator Science and Technology* is dedicated to colliders and provides an in-depth panorama of the different technologies developed since the construction in the 1960s of the first three: AdA in Italy, CBX in the US, and VEP-1 in the then Soviet Union.

Colliders have been crucial for proving the validity of the Standard Model, and they still define the energy frontier in particle physics because at present no machine can overcome the current LHC limit of 13 TeV in the centre of mass.

The book opens with an article by Burton Richter, a pioneer of high-energy colliders, who shares his viewpoint about their future. This is followed by contributions from leading experts worldwide, who discuss the characteristics, advantages and limits of machines that collide different types of particles. Proton–proton and proton–antiproton colliders are reviewed by Walter Scandale, electron–positron circular colliders by Katsunobu Oide,

ion colliders by Wolfram Fischer and John M Jowett, and electron–proton and electron–ion colliders by Ilan Ben-zvi and Vadim Ptitsyn. Akira Yamamoto and Kaoru Yokoya then discuss linear colliders, Robert B Palmer muon colliders, and Jeffrey Gronberg photon colliders.

A section of the book is dedicated to the accelerator physics that form the basis of the design of these machines. In particular, Frank Zimmermann provides a general overview of collider-beam physics, while Eugene Levichev goes into more detail discussing the technologies for circular colliders.

The volume concludes with an article by Kwang-Je Kim, Robert J Budnitz and Herman Winick on the life of Andy Sessler, an accelerator physicist considered by his colleagues as an inspiring figure.

Comprehensive and containing contributions by high-profile experts, this book will be a good resource for students, physicists and engineers willing to learn about colliders and accelerator physics.

Colour: How We See It and How We Use It

By Michael Mark Woolfson

World Scientific



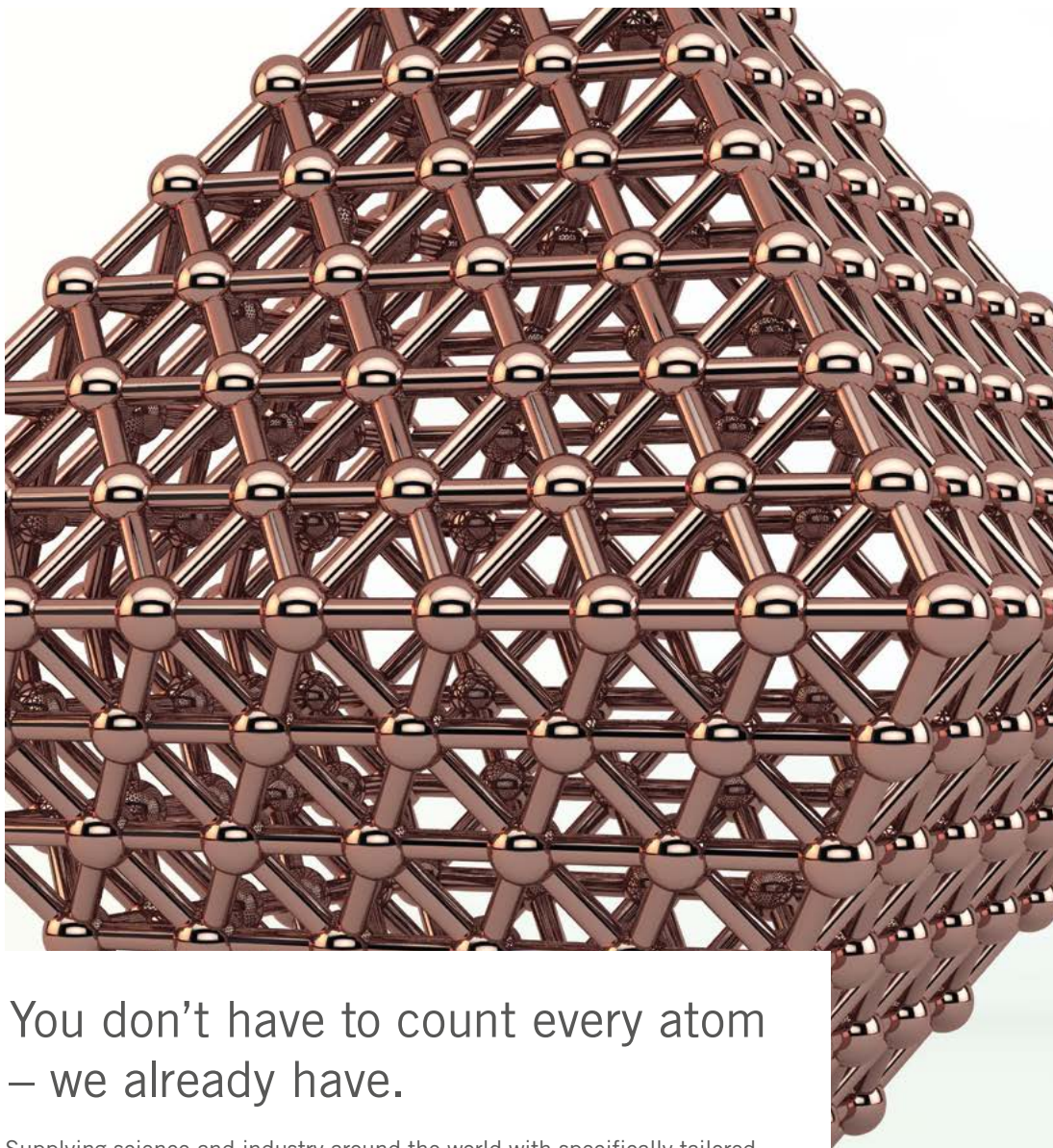
In this book, the author discusses the scientific nature of light and colours, how we see them and how we use them in a variety of applications.

Colours are the way that our vision system and – ultimately – our brain translate the different wavelengths of a part of the light spectrum. Other living things are sensitive in different ways to light and not all of them can see colours.

After presenting the science behind colours and our vision, the book discusses the use that mankind has made of colours. Ever since the time that humans lived in caves, we have used pigments to make graffiti on walls, which evolved into paintings and, lately, graphic art. Here, as is the case when designing decorations and dyes for clothing, the colours are not natural but man-made.

In the chapters that follow, the author reviews three technologies integrated in our everyday life that emerged as black-and-white and evolved into colour by way of photography, cinematography and television. The final part of the book is dedicated to describing various forms of light displays, mostly used for entertainment purposes, and to the application of colours as a code in many contexts – including road safety, hospital emergencies and industry.

Readers attracted by this mixture of science, art and culture will find the book easily readable.



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