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An Introduction to Gauge Theories

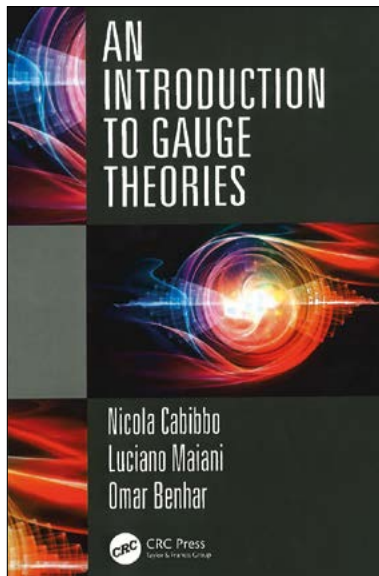
By N Cabibbo, L Maiani and O Benhar

CRC Press

There is always great excitement among the academic community when a new book by renowned scientists is published. Written by leading experts in particle physics, this book by Luciano Maiani and Omar Benhar, with contributions from the late Nicola Cabibbo, does not disappoint in this regard. Former CERN Director-General Maiani co-proposed the GIM mechanism, which is required to suppress flavour-changing neutral currents at the tree level and assumed the existence of a fourth quark that was discovered in 1974 at SLAC and BNL, while Cabibbo proposed a solution to the puzzle of electroweak decays of strange particles, which was later extended to give rise to the Cabibbo–Kobayashi–Maskawa mixing matrix. Omar Benhar, an INFN research director and professor at the University of Rome “La Sapienza”, is expert in the theory of many-particle systems, the structure of compact stars and electroweak interactions of nuclei.

Their book is the third volume of a series dedicated to relativistic quantum mechanics, gauge theories and electroweak interactions, based on material taught to graduate students at the University of Rome over a period of several decades. Given that gauge theories are the basis of interactions between elementary particles, it is not surprising that there are many books about gauge theories already out there – among the best are those written by Paul Frampton, J R Aitchison and Anthony Hey, Chris Quigg, Ta-Pei Cheng and Ling-Fong Li. One might therefore think that it is hard to add something new to the field, but this book introduces the reader in a concise and elegant manner to a modern account of the fundamentals of renormalisation in quantum field theories and to the concepts underlying gauge theories.

Containing more than 300 pages organised in 20 chapters and several appendices, the book focuses mainly on quantum electrodynamics (QED), which – despite its simplicity and limitations – serves as the mould of a gauge theory and at the same time it has a high predictive power and numerous applications. The first part of this treatise deals with the quantisation of QED via the path-integral method, from basic to advanced concepts, followed by a brief discussion on the renormalisation of QED and some of its applications, such as bremsstrahlung, the Lamb shift, and the electron anomalous magnetic moment. The prediction of the latter is considered one of



the great achievements of QED.

In the second part of the book, the authors cover the renormalisation group equations of QED and introduce the quantisation of non-Abelian gauge theories, finishing with a proof of the asymptotic freedom of quantum chromodynamics. Afterwards, the concept of the running coupling constant is used to introduce a few ideas about grand unification. The final chapters are devoted to concepts related to the Standard Model of particle physics, such as the Higgs mechanism and the electroweak corrections to the muon anomalous magnetic moment. Finally, a few useful formulas and calculations are provided in several appendices.

Throughout the book the authors not only present the mathematical framework and cover basic and advanced concepts of the field, but also introduce several physical applications. The most recent discoveries in the field of particle physics are discussed. This is a book targeted at advanced students accustomed to mental challenges. A minor flaw is the lack of problems at the end of the chapters, which would offer students the possibility to apply the acquired knowledge, although the authors do encourage readers to complete a few demonstrations. This text will be very helpful for students and teachers interested in a treatment of the fundamentals of gauge theories via a concise and modern approach in the constantly changing world of particle physics.

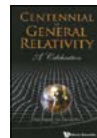
● G Tavares-Velasco, BUAP.

Books received

Centennial of General Relativity: A Celebration

By César Augusto Zen Vasconcellos (ed.)

World Scientific



In 1915 Albert Einstein presented to the Royal Prussian Academy of Sciences his theory of general relativity (GR), which represented a breakthrough in modern physics and became the foundation of our understanding of the universe at large. A century later, this elegant theory is still the basis of the current description of gravitation and a number of predictions derived from it have been confirmed in observations and experiments – most recently with the direct detection of gravitational waves.

This book celebrates the centenary of GR with a collection of 11 essays by different experts, which offer an overview of the theory and its numerous astrophysical and cosmological implications. After an introduction to GR, the Tolman–Oppenheimer–Volkoff equations describing the structure of relativistic compact stars are derived and their extension to deformed compact stellar objects presented. The book then moves to the so-called pc-GR theory, in which GR is algebraically extended to pseudo-complex co-ordinates in an attempt to get around singularities. Other topics covered are strange matter, in particular a conjecture that pulsar-like compact stars may be made of a condensed three-flavour quark state, and the use of a particular solution of the GR equations to construct multiple non-spherical cosmic structures.

Keeping the book contemporary, it also gives an overview of the most recent experimental results in particle physics and cosmology. Several contributions are devoted to the search for physics beyond the Standard Model at CERN, studies of cosmic objects and phenomena through gamma-ray lenses and, finally, to the recent detection of gravitational waves by the LIGO experiment.

Health Physics: Radiation-Generation Devices, Characteristics, and Hazards

By Joseph John Bevelacqua

Wiley-VCH



When developing technologies involving the use of nuclear material or ionisation radiation, a number of safety issues and potential risks have to be addressed. The author



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of this book, a certified health physicist and an expert in radiation protection, discusses these emerging topics related to radiation-generating technologies and associated hazards.

The book opens with a brief overview of modern radiation-protection challenges, before delving into specific areas. First, the author discusses the nuclear-fuel cycle, analysing its steps and related issues such as reactors, new technologies for uranium

enrichment and waste disposal. In the following section, he deals with nuclear accidents and radiological emergencies – making specific reference to the well-known disasters of Three Mile Island, Chernobyl and Fukushima Daiichi – and with the risk of terrorist events involving sabotage or the use of improvised nuclear weapons and devices.

Today, nuclear material is also largely employed for medical imaging and therapies,

thus a part of the book is devoted to these technologies and to the consequent increase of public radiation exposure. Finally, the last section focuses on regulatory issues, limitations and challenges.

Meant for upper-level undergraduate and graduate students of health-physics and engineering courses, the book would also be a useful reference for scientists and professionals working in radiation protection, fuel-cycle technology and nuclear medicine. More than 300 problems with solutions accompany the text and many appendices provide background information.

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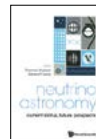
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Neutrino Astronomy: Current Status, Future Prospects

By T Gaisser and A Karle (eds)

World Scientific



This review volume is motivated by the 2014 observation of a high-energy neutrino flux of extraterrestrial origin by the IceCube experiment at the South Pole. The energy of the events recorded ranges from 30 to 2000 TeV, with the latter marking the highest-energy neutrino interaction ever observed. The study of neutrinos originating from violent astrophysical sources enhances our knowledge not only of cosmological phenomena but also of neutrinos themselves.

This book gives an overview of the current status of research in the field and of existing and future neutrino observatories. The first group of chapters present the physics of potential sources of high-energy neutrinos, including gamma-ray bursts, active galactic nuclei, star-forming galaxies and sources in the Milky Way. A chapter is then dedicated to the measurements performed by IceCube, the results of which are discussed in terms of energy spectrum, flavour-ratio and arrival-direction isotropy. Following this, the results of two deep-sea neutrino experiments, ANTARES and Baikal, are presented.

After a brief discussion of other research topics in which the study of high-energy astrophysical neutrinos can play an important role, such as the quest for dark matter, the book examines the next generation of cosmic neutrino detectors. In particular, the future KM3NeT experiment, which will consist of a network of underwater telescopes located in the Mediterranean Sea, and IceCube-Gen2, characterised by unprecedented sensitivity and higher angular resolution compared to IceCube, are described.

Finally, a review of present and in-planning experiments aiming at detecting radio emissions from high-energy neutrino interactions concludes the volume.