

BOOKSHELF

The Standard Model and Beyond by Paul Langacker, CRC Press. Hardback ISBN 9781420079067, £49.99 (\$79.95).

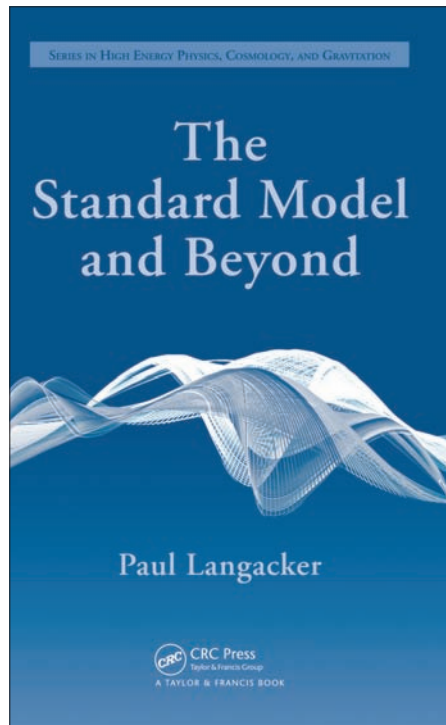
The Standard Model of elementary particles and their interactions via the electromagnetic, weak and strong interactions is a fabulously successful theory. Tests of quantum electrodynamics have been made to a precision at the level of better than one part in one billion; electroweak tests approach the one part in one hundred thousand level; and even tests of quantum chromodynamics, which are intrinsically more challenging, are being made at the per cent level.

Yet, despite this, we are still sure that the Standard Model cannot be the “ultimate” theory. We have yet to account theoretically for the exciting observations of the recent decades, namely, massive neutrinos, dark matter and dark energy, which provide direct evidence for new physics processes. We cannot account for the observed patterns of the masses of the fermion building blocks of matter, their manifestation in three generations or “families”, the “mixing” between the generations, or why the universe seems to contain almost no antimatter. And we don’t yet understand how to incorporate gravity in terms of a quantum-field theory.

Theoreticians have not been idle in developing models of the new physics that could underlie the Standard Model and that ought to manifest itself at the tera-electron-volt energy scale, such as alternative spontaneous electroweak symmetry-breaking mechanisms, supersymmetry and string theories, for example. However, within the framework of the Standard Model itself, we have yet to observe the Higgs boson, the presence of which is required to account for the generation of the masses of the W and Z particles.

This substantial book – at more than 600 pages – gives a detailed and lucid summary of the theoretical foundations of the Standard Model, and possible extensions beyond it.

Chapter 1 sets up the required notations and conventions needed for the ensuing theoretical survey. Chapter 2 reviews the basics of perturbative field theory and leads, via an introduction to discrete symmetry principles, to quantum electrodynamics. Group theory, global symmetries and symmetry breaking are reviewed in Chapter 3, which forms the foundation for



the presentation of local symmetries and gauge theories in Chapter 4, where the Higgs mechanism is first introduced.

The heart of the book lies in Chapters 5 (strong interactions), 6 (weak interactions) and 7 (the electroweak theory), which at more than 170 pages is the most substantial. These chapters present a clear theoretical discussion of key physical processes, along with the phenomenology required for a comparison with data, and a brief summary of the relevant experimental results. Precision tests of the Standard Model are summarized, and the framework is introduced for parametrizing the head-room for new physics effects that go beyond it.

The final chapter summarises the known deficiencies of the Standard Model and introduces the well developed extensions: supersymmetry, extended gauge groups and grand unified theories. Fortunately, now that the LHC is up and running, we should expect to start to address experimentally at least some of these theoretical speculations. LHC results will provide the sieve for filtering the profound and accurate, versus the merely beautiful and mathematically seductive, models of nature.

The book ranges over huge swathes of theoretical territory and is self-consciously broad, rather than deep, in terms of coverage.

I heartily recommend it to particle physicists as a great single-volume reference, especially useful to experimentalists. It also provides a firm, graduate-level foundation for theoretical physicists who plan to pursue concepts beyond the Standard Model to a greater depth.

Philip Burrows, John Adams Institute, Oxford University.

At the Leading Edge: The ATLAS and CMS LHC Experiments by Dan Green (ed.), World Scientific. Hardback ISBN 9789814277617, £79 (\$120). Paperback ISBN 9789814304672, £38 (\$58).

At the Leading Edge is the latest book edited by Dan Green, who is already well known as the editor of earlier books, such as *High p_T Physics at Hadron Colliders* (CERN Courier November 2005 p56). His new book is addressed to physicists and graduates in particle physics and it appears just in time for the first physics runs at LHC. With it he adds a new angle to the descriptions and information that are already available about the detectors and physics of the LHC. Green, from Fermilab, is currently chair of the CMS collaboration board.

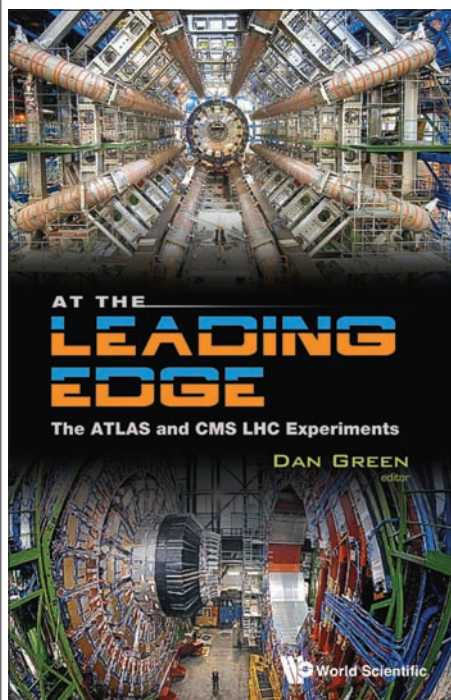
In contrast to conference proceedings, where one might find detailed reports about the LHC-detector hardware and read-out chains, this book follows a new concept, which makes it unique and interesting to read. In Green’s own words the book aims at explaining why the LHC detectors are – almost necessarily – conceived the way that they are, given the experimental environment of the LHC and the physics questions to be answered. It is also instructive to have two detectors, ATLAS and CMS, treated side by side in the same book because this emphasizes the complementary approach of the different technological choices for the various subdetectors.

Following the concept and logic of the book, the introduction, which was written by Green himself, describes “how physics defines the LHC environment and detectors”. He has also written two chapters, which cover global detector properties and generic detector subsystems. The actual technological choices made by the collaborations to address the physics at the LHC are outlined by subsequent well written and illustrated contributions from 22 prominent scientists, engineers, experts and leaders responsible for the detector subsystems of ATLAS and CMS. The book

contributes in an impressive way towards understanding the motivation behind specific choices, and towards learning about the risks and the courage required to tackle necessary technological developments. Several authors evaluate the challenges and the mistakes made during 15 years of R&D and construction at the end of their contributions in a paragraph on “Conclusions and lessons learnt”.

Despite the historical background of the formation of LHC collaborations, the influence of committees and panels and of the leading physicists – or, as one of the authors puts it, “the cultural bias of the physicists involved” – on some of the technological choices and, last but not least, the constraints of cost and competences, the contributors nevertheless convince the reader that the technological choices at the leading edge all followed the same concept. This was to build a detector that is best matched to the experimental environment at the LHC and that allows all of the data to be extracted from collisions at the tera-electron-volt scale, so as to reach the physics goals of the collaborations.

In summary, and repeating what I wrote in reviewing *The Large Hadron Collider: a Marvel of Technology*, edited by Lyn Evans (CERN Courier October 2009 p39), both that book and this one edited by Dan Green should be on the shelf of all friends of the LHC. Each



book represents a nicely balanced record of the historical developments, technical challenges and scientific background, and both are packed with photos of the LHC machine and its two major general-purpose detectors, ATLAS and CMS, taken during construction and assembly.

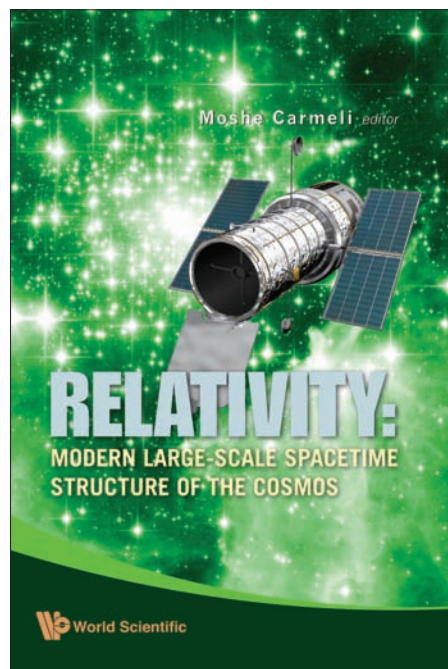
Horst Wenninger, CERN.

Relativity. Modern Large-Scale Space-time Structure of the Cosmos by Moshe Carmeli (ed.), World Scientific. Hardback ISBN 9789812813756 £61 (\$110).

Before speaking about the content of this book edited by Moshe Carmeli, I would like to say some words about its form. Many chapters are at the level of some advanced draft, the reason being that Carmeli passed away before the final version was ready for the press. Much of the material is repeated several times almost with the same wording, which is really both annoying and unfortunate, because the book is worth reading from the beginning to the end. I hope many people will be patient enough to do so.

The text covers in detail an extended version of Einstein's relativity theory, developed by Moshe Carmeli and refined by the authors of the different chapters, in which space-time is extended by adding a fifth dimension, connected with the evolution of the cosmos. Because the theoretical construction of such a theory proceeds by analogy with Einstein's special and general relativity, the book happens also to be an excellent text on these latter theories. Though this may sound paradoxical, it actually makes sense: the authors need to reproduce the successful predictions of Einstein's theories, while at the same time they want to emphasize the differences. From this point of view, chapters 8–10 and 13–14 have most importance because they highlight what can be done on the experimental side to distinguish between cosmologies based on Einstein's or Carmeli's theories.

Though I found a few points that are not very convincing – although I admit that I might have misinterpreted some explanation, which would have become clearer in a more refined version of the text – I would still like to recommend the book, at least for the following reasons (in order of my personal taste). First, Carmeli's theory adds as a fifth dimension the velocity of the cosmic expansion, postulating that the Big Bang



time is a universal constant for all observers (in particular, at any time). Second, the cosmology based on Carmeli's theory automatically produces a flat 3D space with Euclidean metric (which is indeed what we observe) though the global 5D space may have different curvatures. Third, galaxy rotation curves are reproduced assuming that Newton's gravitation holds whenever the effect of cosmic expansion can be neglected (i.e. at the core of the galaxy) while a correction takes over when the latter cannot be neglected (far enough from the core), inducing a slower decrease of the gravitational attraction with increasing distance. In particular, this means that no dark matter needs to be assumed to explain the Tully-Fisher law on the rotation velocity of the stars inside a galaxy. Fourth, no dark matter (or cosmological constant) is needed at cosmic distances because the redshift of the supernovae of Type Ia can be made to fit very well in the context of Carmeli's cosmology if the fraction of the total energy density from matter is 0.04, which is compatible with the constraints set on the baryonic matter. Finally, the propagation of gravitational waves is different from Einstein's general relativity: when the cosmic expansion cannot be neglected, the intensity of the waves is dumped. This means that the detection of gravitational waves emitted by galactic sources (e.g.

rotating binary pulsars) should be possible whereas extragalactic sources should be hardly visible.

Diego Casadei, New York University and CERN.

Introduction to Relativistic Heavy Ion

Physics by J Bartke, World Scientific. Hardback ISBN 9789810212315, £36 (\$65).

This book sets out to cover several facets of what is commonly known as “heavy-ion physics”, mainly from an experimentalist’s point of view. It is based on lectures given by the author in Krakow, over many years. The text is written in an informal and qualitative style, complemented by figures that, as the preface indicates, aim to capture “the main features of experimental data”. This is often by means of preliminary versions of the results, as presented in conference proceedings rather than by citations from the final publications.

The book starts with a few introductory chapters that remind the reader, among other things, of some basic properties of atomic nuclei. For instance, we are told that, contrary to what happens in heavy nuclei, the spatial distribution of neutrons in light nuclei is narrower than that of protons, because of the repelling Coulomb forces between the latter. The absence of a reference for further reading is presumably intentional, given

the introductory character of the text, which targets a young audience. These first chapters are of a generic nature, as they present typical experimental apparatus and basic concepts about cross-sections, charged-particle multiplicities and spectra.

The later chapters are devoted to a few more specific physics topics. Naturally, considerable emphasis is given to the studies made by the experiments with which the author has worked: NA35 and NA49 at CERN’s Super Proton Synchrotron. Many pages focus, in particular, on the topics of strangeness enhancement, pion interferometry and collective flow, where these two experiments made seminal contributions. The final chapter looks forward to heavy-ion collisions at the LHC and presents some predictions for what may be expected in the new energy regime. *Carlos Lourenço, CERN.*

Books received

Introduction to Nanoscience by S M Lindsay, Oxford University Press. Hardback ISBN 9780199544202, £69.95 (\$99). Paperback ISBN 9780199544219, £35 (\$59.95).

Nanoscience is not physics, chemistry, engineering or biology. This text, aimed at advanced undergraduates and beginning graduate students, sets out to integrate the disciplines. The book is divided into three parts. Part I (The Basics) is a self-contained introduction to quantum mechanics, statistical mechanics and chemical kinetics, and calls for no more than basic calculus. The conceptual approach and an array of examples and problems will allow even those without the mathematical tools to grasp much of what is important. Part II (The Tools) covers microscopy, single-molecule manipulation and measurement, nanofabrication and self-assembly. Part III (Applications) covers electrons in nanostructures, molecular electronics, nano-materials and nanobiology.

Relativity, Gravitation and Cosmology: A Basic Introduction, 2nd edition, by Ta-Pei Cheng, Oxford University Press. Hardback ISBN 9780198529569, £64 (\$99). Paperback ISBN 9780198529576, £27 (\$49.95).

Einstein’s general theory of relativity is introduced in this textbook aimed at advanced undergraduates and beginning graduate students. The author presents the subject initially with an emphasis on

physical examples and simple applications, saving the full tensor approach for later. The reader learns first how to describe curved space–time, and at this mathematically more accessible level can already study interesting phenomena such as gravitational lensing, precession of Mercury’s perihelion, and black holes, as well as cosmology. The full tensor formulation is presented later, when the Einstein equation is solved for a few symmetric cases. Many modern topics in cosmology are also discussed, from inflation and cosmic microwave anisotropy to the “dark energy” that propels an accelerating universe.

Computing with Cells: Advances in Membrane Computing by Pierluigi Frisco, Oxford University Press. Hardback ISBN 9780199542864, £50 (\$99).

Membrane systems are a new class of distributed and parallel models of computation inspired by the subdivision of living cells into compartments delimited by membranes. Membrane computing – the study of membrane systems – is a fast-growing area of research. The main streams of current investigations concern theoretical computer science and the modelling of complex systems. In this monograph the author considers the former trend and presents an in-depth study of the formal language and computational complexity of the most widely investigated models of membrane systems. The text provides a comprehensive understanding of the computational power of the models considered, which cover a range of features.

The Origin of Discrete Particles by T Bastin and C W Kilmister, World Scientific. Hardback ISBN 9789814261678, £51 (\$68). Online version ISBN 9789814261685, \$88.

Volume 42 in the Series on Knots and Everything, this book is a summary of the results of a long research project undertaken by the authors on discreteness in modern physics. In contrast to the usual expectation that discreteness is the result of mathematical tools for insertion into a continuous theory, this more basic treatment builds up the world from the discrimination of discrete entities. This gives an algebraic structure in which certain fixed numbers arise. As such, one agrees with the measured value of the fine-structure constant to one part in 107.

