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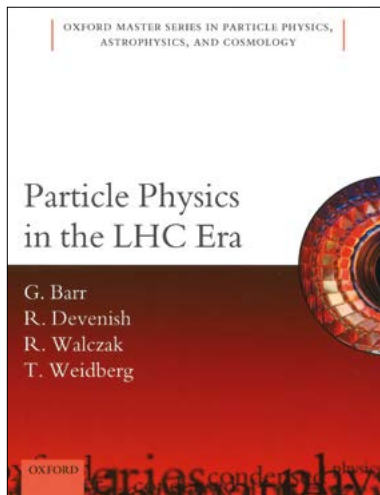
Particle Physics in the LHC Era

By G Barr, D Devenish, R Walczak and T Weidberg
Oxford University Press

This book's aim, as stated in the introduction, is to provide a practical introduction to particle physics in the LHC era at the level of an advanced undergraduate or introductory graduate course. Indeed, in its almost 400 pages, it covers a wide range of topics, from instrumentation and detector technologies to some mathematical techniques and the traditional particle-physics topics that are usually included in similar textbooks. It hovers, by design, at the border between the established textbooks aimed at undergraduates and the more advanced graduate texts that often start with quantum field theory.

Following the introduction, the book commences with a three-chapter sequence with somewhat technical content. Chapter 2, dedicated to mathematical methods, covers discrete symmetries, angular momentum and rotations in space, Lorentz invariance and the calculation of phase-space factors, decay widths and cross-sections, and concludes with a brief review of group theory. Chapter 3, on accelerators, includes a concise yet clear description of the basic concepts and terminology often encountered by students starting to work on experiments but not readily available. The topics include synchronicity, beam optics, Q values and beam tunes, luminosity, and even some characteristics of past accelerators. Chapter 4 is on particle detectors. Beyond the standard topics expected in such an overview, e.g. the interaction of particles and radiation with matter, the chapter includes topics that are usually neglected, including short presentations on signal generation, triggering of experiments and the selection of a magnetic field. As would be expected, calorimetry is well covered, as are tracking detectors, to which an extensive description, including an introduction to solid-state detectors, is included. The topics and detector examples provided are too centred on the LHC and its experiments, though.

Chapter 5, on the static quark model, is the first "particle-physics-proper" section. It's a clear and self-contained introduction to mesons and baryons, with a modern perspective. The authors have decided to include heavy quarks (with the exception of the top quark) and their mesons and baryons, and the result is a full overview for the reader. Finally, chapter 6 on relativistic quantum mechanics concludes what could be called the first part of the book on



"concepts, tools and methods". There is a modern angle in this chapter: as an example, Weyl spinors are introduced and used, along with the associated Lorentz transforms and spin matrices. This material is better absorbed by graduate students. The rest of the chapter covers the traditional Klein-Gordon and Dirac equations, and introduces the electromagnetic interaction. It concludes with a short introduction to gauge symmetry.

Chapters 7–10 constitute a second part that concentrates on particle physics. Chapter 7, on weak interactions, covers all of the material from the four-point Fermi interaction to the Standard Model (SM), although without symmetry breaking. The descriptions of V–A, parity violation and the weak interactions of quarks, the CKM matrix and hadron decays via the weak interaction are clear, as is the extended introduction of $SU(2) \times U(1)$ symmetry as the basis of the SM. Chapter 8, on experimental tests of electroweak theory, is one of the more modern presentations of the topics covered: it starts with neutrino interactions and charged and neutral currents, and moves to Z physics and then WW production at LEP. It includes some experimental aspects such as the use of resonant depolarisation for the precise determination of the LEP beam energy. Moving away from convention, the discovery of the W and Z bosons at the CERN SPS is left for after the LEP presentation. The chapter concludes with a brief presentation of the discovery of the top quark and some later results from the Tevatron.

Chapter 9, on dynamic quarks, breaks the flow slightly. It contains Rutherford

scattering, the quark–parton model and neutrino interactions, and concludes its first part with electron–nucleon deep inelastic scattering. This is a departure from standard practice in most textbooks. The second part of the chapter is on the introduction of colour, QCD, parton distribution functions and hadron–hadron collisions, and the Drell–Yan process. The material, which is extensive but presented quite briefly, is more appropriate for undergraduates.

Chapters 10 (oscillations and CP violation in meson systems) and 11 (neutrino oscillations) are great introductions to physics mixing, both in the quark and the lepton sector. The discussion in chapter 10 is modern, with results from experiments at LEP, the B factories and hadron colliders. Chapter 11 has one of the best summaries on neutrino physics for this level: it starts with the first evidence of mixing in atmospheric neutrinos, and proceeds to laboratory experiments, and then the MSW effect, solar-neutrino oscillations and then three-flavour oscillations, concluding with the measurement of θ_{13} . This chapter is a novel and useful addition to the textbook.

Chapter 12 is on the Higgs boson. It starts with a short introduction to spontaneous symmetry breaking and proceeds to a description of the discovery of the Higgs boson by the ATLAS and CMS experiments. The material, with the exception of a section on the statistical significance, which is too short and ill-placed to be useful, is at the right level for the advanced-undergraduate-to-graduate student audience.

The book concludes with chapter 13 on the LHC and BSM (physics Beyond the Standard Model). It has an interesting selection of topics, including expected ones like supersymmetry and some unexpected ones (for a textbook) like the search for new contact interactions and new resonances. The approach is quite experimental in that only the motivation for new phenomena is presented, and the theory is skipped. It is nevertheless a useful introduction to the subject, adequate for motivating students to explore further.

Overall, the book achieves its goal of bridging the gap between undergraduate and graduate textbooks. The descriptions of the various topics are mostly clear, although at times too short. In a formal course, the tutor would probably choose to cover the material in a slightly different mix to the order it is presented here, combining material from the first part (chapters 2–6) and the second

Bookshelf

part (mainly chapters 7–10). In summary, this is a welcome, useful and modern addition to the current list of textbooks in particle physics.

● *Paraskevas Sphicas, CERN, and University of Athens, Greece.*

Tutorials in Radiotherapy Physics: Advanced Topics with Problems and Solutions

By Patrick N McDermott

CRC Press

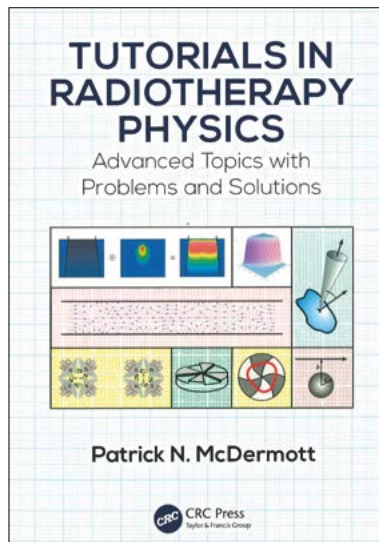
This book addresses five selected physics topics in modern cancer radiation therapy. Examining them in more detail than can be found in standard medical-physics textbooks, the author has also formulated and solved a large number of exercises that are provided at the end of each chapter, together with a detailed bibliography.

Despite its title, the book is not a substitute for comprehensive textbooks in medical-radiation physics, rather it complements them. It is therefore of interest to experienced medical physicists who would like to better understand the physics of their daily work, as well as to young researchers approaching this discipline for the first time, often following a PhD in particle physics.

The first section deals with the main tool of modern cancer radiation therapy: the electron linear accelerator (linac). Starting from the basics of electrodynamics, travelling- and standing-wave linear accelerators are discussed together with resonating cavities. Particular care is given to mathematical formulations and to the definition of symbols. This chapter could also appeal to accelerator physicists willing to know more about electron acceleration at energies of a few MeV.

Proton therapy, which is generally considered an advanced topic in medical radiation therapy, is approached in a somewhat easier way. Starting from an historical introduction, emphasis is given to accelerators and to dose-distribution systems, with a glimpse of future developments. It is a pity that carbon-ion therapy is not mentioned and that active dose-distribution systems are not discussed in more detail.

The two topics that follow address the daily work of the medical physicist. Dose-computation algorithms are treated following a careful mathematical formulation complemented by examples and references to practical cases. Deterministic radiation transport is introduced, starting from the basic quantities used in medical radiation physics. The transport and Fermi–Eyges equations are then derived and discussed.



The last theme, tumour control and normal tissue complications, is the most relevant for the patient. Is the therapy effective? What is the quality of life after treatment? The answers to these questions may be searched for using the bridge that connects physics to medicine. To accomplish this task, models are necessary. Starting from the concepts of probability and of dose-volume histograms, empirical and mechanistic models are presented together with the serial and parallel architecture of the organs in the human body.

The application of radiation physics to medicine is an expanding multidisciplinary field based on knowledge, tools and techniques derived from nuclear and particle physics. This book will therefore appeal not only to curious medical physicists and scientists active in the field, but also to physicists in general who – as the author comments – “like understanding”.

● *Saverio Braccini, AEC-LHEP, University of Bern, Switzerland.*

Books received

Lectures in Nonlinear Mechanics and Chaos Theory

By Albert W Stetz

World Scientific



This concise book provides a rigorous introduction to the theory of nonlinear mechanics and chaos, suitable for students across physics, mathematics and engineering.

Nonlinear dynamics treats problems that cannot be “solved”, in the sense that it is not possible to derive equations of

motion that describe the positions of the various parts of a system as functions of time using standard analytic functions. If, on one side, the formulations of mechanics of Lagrange and Hamilton lead to systems that cannot be solved in the usual sense of the word, perturbation theory, in turn, fails in providing approximate solutions because of the problem of small dividers. This is the path that led originally to the discovery of chaos, and it is the one that the author pursues in the book.

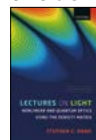
The first part is dedicated to the basic concepts of the Lagrangian and Hamiltonian formulation of mechanics, and to canonical transformations. The author then deals with more advanced topics, including Liouville’s theorem and perturbation theory. In the third part of the book, the modern theory of chaos is introduced. The author describes chaotic motion using the tools of discrete maps and Poincaré sections, along with the Poincaré–Birkhoff and Kolmogorov–Arnold–Moser (KAM) theorems and their applications.

Each chapter is accompanied by a set of problems, with the last section providing more advanced projects that require some expertise in computing. As a conclusion, an appendix discusses the relevance of the KAM theorem to the ergodic hypothesis and the second law of thermodynamics.

Lectures on Light: Nonlinear and Quantum Optics using the Density Matrix (2nd edition)

By Stephen C Rand

Oxford University Press



The aim of this book is to bridge the gap between introductory quantum mechanics and the most recent advances in modern optics.

The author opts for an unconventional approach. Rather than providing an exhaustive treatment, he introduces a single analytic tool – the density matrix – to analyse complex optical phenomena and applies it to a wide range of problems. Among the many mathematical tools available to treat nonlinear and quantum optics, he chooses the density matrix because it is extremely versatile and applicable virtually to any problem. In particular, it is well suited for dealing with coherence in isolated or interactive systems, and allows researchers to ignore parts of a problem that appear irrelevant.

After covering the basics, the book quickly passes to more sophisticated topics. It starts with the simplest systems (stationary two-level atoms) and then introduces atomic motion and additional

energy levels, and continues with a discussion of coherence effects effects (of first-, second- and third-order).

Finally, a section is dedicated to selected examples from recent research topics in which the use of the density matrix is profitable, including laser tweezers, laser cooling, coherent population trapping and transfer, optical magnetism, electromagnetically induced transparency, squeezed light and quantum information processing.

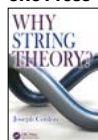
The text is based on two decades of lectures and is oriented to graduate students not only of traditional disciplines such as physics, chemistry, electrical engineering and materials science, but also of interdisciplinary courses such as biophysics, biomedicine and photochemistry.

In this second revised edition, new sections on quantum interference, Fano resonances, optical magnetism, quantum computation, laser cooling of solids, and irreducible representation of magnetic interactions have been included, along with more than 40 new problems.

Why String Theory?

By Joseph Conlon

CRC Press



As the author himself states, the primary aim of this book is to explain why so many scientists choose to work on a theory that has no direct experimental support and is unlikely to have so anytime soon.

String theory, the origins of which date back to 1968, has developed into a major component of theoretical particle physics. It is most famous as a theory of quantum gravity and as a candidate unified theory of fundamental interactions at the smallest scales – so small that, unfortunately, we cannot directly test it with experiments.

Although string theory is built on a very solid mathematical basis and allows rigorous calculations, the author uses almost no equations. Rather than a textbook, this is a book on the history, science and philosophy lying behind a fascinating and speculative theory.

In the first part, the theory of quantum-mechanical relativistic strings is placed within the broader context of theoretical particle physics, and ultimately science in general. It is then discussed why there is still a need for ideas and paradigms that go beyond what we already know, and why string theory is a candidate for being a global theory that includes all others. Following this, the author describes the motivation driving this field and how this has

evolved during the past 50 years. In particular, he dedicates various chapters to the connections of string theory with quantum field theory, mathematics, cosmology, particle physics and quantum gravity.

The last part of the book discusses the social aspects of science: the diverse ways of approaching the topic as well as various personal driving forces. A chapter is also dedicated to the most significant criticisms of string theory, to which the author provides a reply.

The book is intended to appeal to laypersons interested in fundamental physics as well as to physics students, so the author chooses to avoid mathematical formulations of the theory. However, the risk is that the book is then not sufficiently clear and explanatory to be an easy read for non-experts, nor technical and detailed enough to appeal to students.

Exactly Solvable Models in Many-Body Theory

By N H March and G N Angilella

World Scientific



Following their previous book on many-body theory, the authors have written a new volume focused on exactly solvable models, to add to the literature in this field. Several theoretical models are presented for selected systems in condensed states of matter – including solid, liquid and disordered states – and for systems of few or many bodies.

The book starts with an introduction to low-order density matrices, then discusses exactly or nearly exactly solvable models for several few-particle systems. The material is arranged according to the statistics of these particle assemblies, going from small clusters of fermions to small clusters of bosons – with specific reference to Efimov trimers in nuclear and condensed-matter assemblies – to anyon statistics.

The second group of chapters is dedicated to models for selected many-body systems in condensed matter, where particular attention is given to superconductivity and superfluidity, and to isolated impurities in a solid. Pair-potential and many-body force models for liquids are also discussed, as well as disorder and its implications for transport in solids.

The authors then deal with more general topics, in particular statistical field theory (discussing some specific models and critical exponents) and relativistic field theory. Open problems in quantum gravity are also briefly reviewed in the concluding chapter, and several appendices are included at the end of the book.

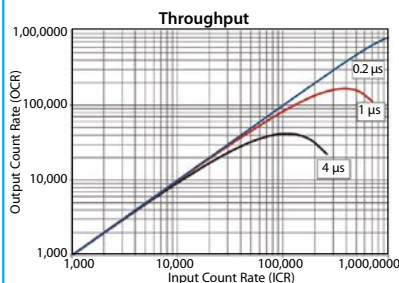
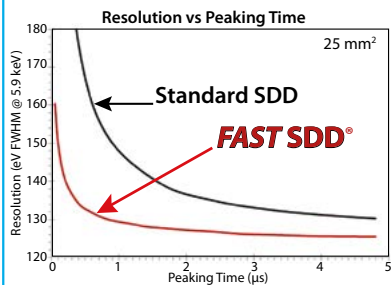
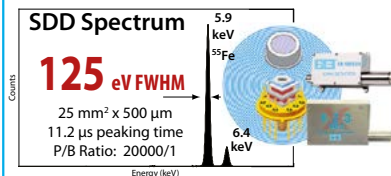
Silicon Drift Detectors

- Solid State Design
- Easy to Use
- Low Cost

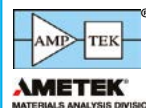
FAST SDD®

Count Rate = >1,000,000 CPS

Resolution	Peaking Time
125 eV FWHM	4 μ s
130 eV FWHM	1 μ s
140 eV FWHM	0.2 μ s
160 eV FWHM	0.05 μ s



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