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Advanced Topics in Quantum Field Theory: A Lecture Course

By M Shifman

Cambridge University Press

Hardback: £45 \$80

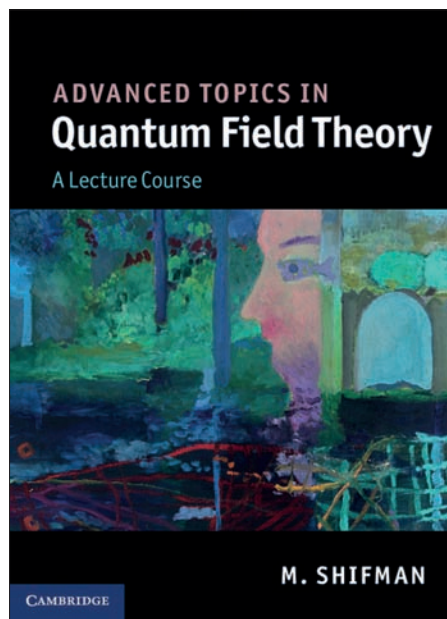
E-book: \$64

Many interesting developments have taken place in quantum field theory (QFT) since the 1970s, and there is no better place to learn about them than this book. The author has been an active contributor to the field over the past four decades and he has produced a personal book based on his lectures over the years. Reading the table of contents virtually gives you vertigo because the depth and breath of the topics covered is simply staggering.

The book is structured as two parts: before and after supersymmetry – although many of the concepts introduced in the first part have an extension in the supersymmetric context, with interesting conceptual variations. All subjects are treated thoroughly and with great clarity. The opening chapter deals with the important subject of the phases of gauge theories and it continues with the many exotic objects that populate QFT, namely kinks, domain walls, strings, vortices, monopoles, skyrmions, instantons, chiral anomalies, confinement, chiral-symmetry breaking and a quick overview of lower-dimensional models related to the theory of phase transitions. The treatment of each subject is rather complete, and many difficult subjects are explained with exemplary clarity, for example the use of collective co-ordinates and their importance in the quantization of semiclassical states, as well as the interplay between chiral-symmetry breaking in QCD-like theories and confinement.

The author provides one of the most elegant and concise presentations of the use of instantons in gauge theories that I have ever seen. This is a notoriously complex subject, with important physical implications, such as the vacuum angle in QCD and the strong CP problem. The computations are carried out in detail and the reader is led by a safe hand through all of the delicate aspects of rather complex calculations. This is a great service to anyone trying to learn advanced QFT after a grounding in the standard courses in the subject.

In the second part of the book, the author provides a remarkably lucid and complete presentation of supersymmetry, supersymmetric gauge theories and all of their associated phenomenology. It is



difficult to pack more information in the 150 pages dedicated to the subject. The phase diagram of supersymmetric gauge theories is rather complex and subtle. There is no one better suited than the author to introduce the subject; he has been one of its main contributors over the years. Subjects such as supersymmetry anomalies, the Witten index, the implications and uses of instantons within supersymmetry, the super-Higgs mechanism and the Russian beta-function are but a few of the subjects featured in this part of the volume.

This book is a must for anyone interested in learning about the developments in advanced field theory over the past few decades. It is a pedagogical and deeply insightful presentation by one of the masters in the field.

● Luis Álvarez-Gaumé, CERN.

Supergravity

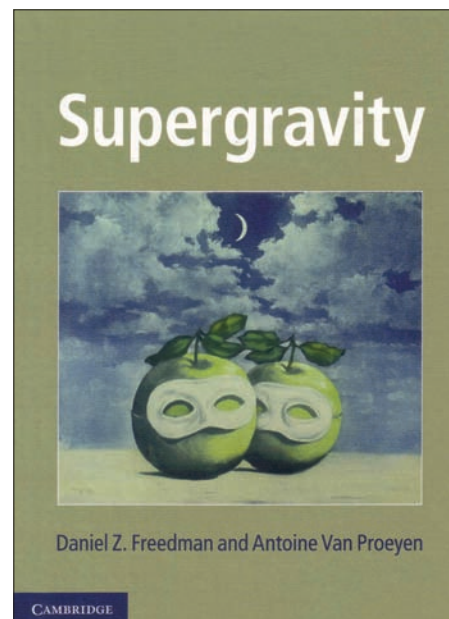
By Daniel Z Freedman and Antoine Van Proeyen

Cambridge University Press

Hardback: £45

E-book: \$64

Since the work of Emmy Noether nearly a century ago, the idea of symmetry has played an increasingly important role in physics, resulting in spectacular successes such as Yang-Mills gauge theory along the way. Albert Einstein, in particular, realized that symmetry could be a foundational principle; his understanding that the space-time dependent ("local") symmetry of general co-ordinate invariance could be used to build general relativity had an



enormous impact on the development of 20th-century physics.

The current zenith of the local symmetry principle is the theory of supergravity, which combines general relativity with the spin-intermingling theory of supersymmetry to construct the richest and deepest symmetry-based theory yet discovered. Supergravity also lies at the foundation of string theory – a theory whose own symmetry principle has not yet been uncovered – and so is one of the central ideas of modern high-energy theoretical physics.

Unfortunately, since its invention in the 1970s, supergravity has been an infamously difficult subject to learn. Now, two of the inventors and masters of supergravity – Dan Freedman and Antoine Van Proeyen – have produced a superb, pedagogical textbook that covers the classical theory in considerable depth.

The book is notably self-contained, with substantial and readable introductory material on the ideas and techniques that combine to make up supergravity, such as global supersymmetry, gauge theory, the mathematics of spinors and general relativity. There are many well chosen problems for the student along the way, together with compact discussions of complex geometry. After the backbone of the book on $N=1$ and $N=2$ supergravities, there is an excellent and especially clear chapter on the anti-deSitter supergravity/conformal field theory correspondence as an application.

Naturally, any finite book has to cut

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short some deserving topics. I hope that any second edition has an expanded discussion on superspace to complement the current, clear treatment based on the component multiplet calculus, as well as a greater discussion on supergravity and supersymmetry in the quantum regime.

Overall, this is a masterful introduction to supergravity for students and researchers alike, which I strongly recommend.

● John March-Russell, University of Oxford.

Extreme States of Matter in Strong Interaction Physics: An Introduction

By Helmut Satz

Springer

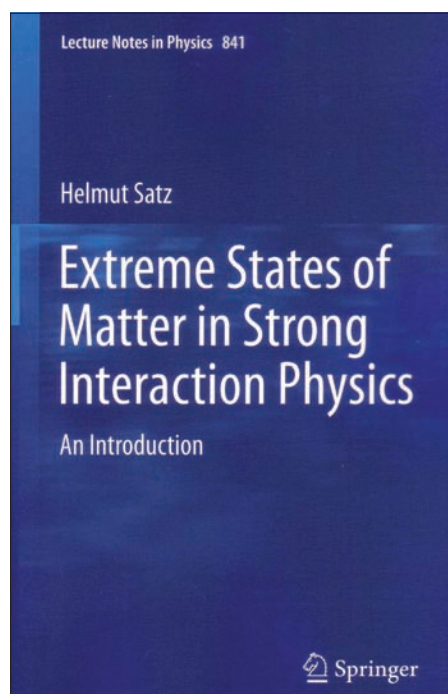
Paperback: £40.99 \$59.95 €44.95

E-book: £38.99

Helmut Satz is a leading figure in the field of strong interactions in extreme conditions, having provided many original ideas that played a crucial role in the design of various experiments studying high-energy heavy-ion collisions. His most famous paper (with Tetsuo Matsui), proposing that quarkonium suppression should signal quark–gluon plasma formation in high-energy nuclear collisions, has acquired an exceptional status in this area of physics and accumulated more than 1600 citations since its publication in 1986 – surely an impressive achievement. However, the status of Satz in the heavy-ion community extends far beyond the impact of that one paper. His contributions are many, varied and often thought-provoking (sometimes, simply “provocative” would be a suitable qualifier). In particular, he often brings to discussions on “quark–gluon plasma physics” interesting concepts borrowed from other branches of physics (and mathematics). These trigger new ways of looking at old puzzles, with the important by-product of attracting new and creative minds to the field.

Another outstanding facet of Satz’s personality is his brilliance as a speaker and writer. Over the past 25 years, I have attended tens of talks and lectures by him and I am amazed every time by the quality of his communication skills. The topics are always presented in crystal-clear and pedagogical ways that grab the attention of the audience. He always seems to have something new to say, making each talk worth attending. Discussions over a glass of wine are also truly captivating, even if it can be daunting to convince him of something that does not fit with his convictions.

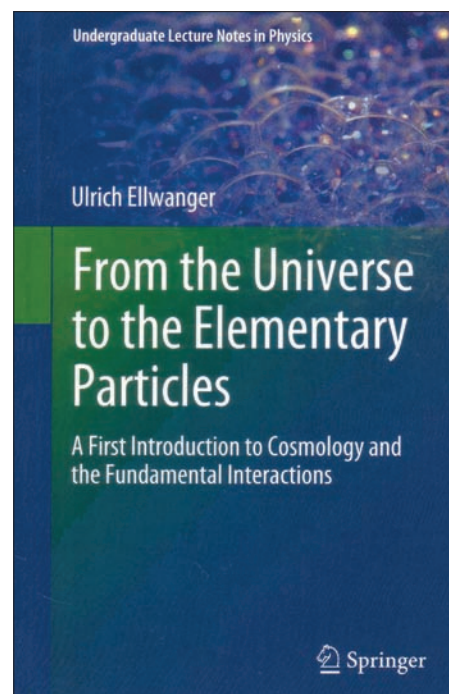
In publishing *Extreme States of Matter in Strong Interaction Physics*, in Springer’s series “Lecture Notes in Physics”, Satz has done a wonderful service to the community of people working on QCD



thermodynamics. The book presents a range of concepts, from statistical physics to particle and nuclear physics, covering critical behaviour and phase transitions, lattice QCD at nonzero temperatures or large baryon densities, deconfinement and chiral symmetry restoration, etc. It provides the reader with the background knowledge needed to understand the main properties of the quark–gluon plasma, a new state of strongly interacting matter, the study of which currently drives several thousands of physicists, engineers, technicians and students at CERN, Brookhaven and elsewhere.

These lecture notes have been prepared over a period of many years and “tested” in front of a multitude of audiences, in physics schools organized on several continents. The students in Bielefeld and Lisbon, where Satz lectured over long periods, must have been particularly helpful in shaping the arguments, which are presented in a clear and pedagogical style. Reflecting the author’s multifaceted culture and broad interests, the book also includes well justified digressions, such as the one through black holes and Hawking–Unruh radiation, and its relation to thermal multihadron production in high-energy collisions.

I wonder if the book warrants the subtitle “An Introduction”, given the detail of the exposition; Satz is not shy when it comes to filling pages and pages with non-trivial equations. Nevertheless, it is true that the field commonly known by the (unfortunate) label “heavy-ion physics” has become so



diversified and complex that it cannot be covered fully in a single book. This justifies the author’s choice of concentrating on concepts and theory – the experimental side being mentioned only at a rather cursory level. Given the recent burst of results from the LHC experiments, of surprisingly high quality after only two lead-ion runs, he may soon need to begin writing a sequel. He certainly has the necessary energy and his pencil remains as sharp as ever.

In conclusion, this is a remarkable book, which I highly recommend to whomever wants to study “QCD matter” and related topics. I will keep it right next to another excellent textbook, *Ultrarelativistic Heavy-Ion Collisions* (Elsevier 2007), also written by a leading expert in the field, Ramona Vogt, who shares with Satz the talent of writing in exceptionally clear and proficient English. Apart from the pleasure of learning about interesting physics, it is a delight to read well written books such as these.

● Carlos Lourenço, CERN.

From the Universe to the Elementary Particles: A First Introduction to Cosmology and the Fundamental Interactions

By Ulrich Ellwanger

Springer

Paperback: £40.99 \$59.95 €44.95

E-book: £38.99

This is an ambitious book, reaching out to a broad readership on the topics of cosmology and elementary-particle physics.

In appearance and style it comes across as a textbook, including equations and simple exercises after each chapter. The level of mathematics required includes vector calculus and simple differential equations. In Germany, at least, there is no course in the university curriculum that it could correspond to, although I understand that in France there is.

It can also be considered a popular book including equations. This is supposedly an oxymoron – like “jumbo shrimp” – but more recently several blogs on particle physics that include a significant amount of maths have become quite popular with a non-professional audience. I also have non-physicist friends who want to get beyond the words and more into the (mathematical) details, although vector calculus might be pushing it a little too far.

All the same, I found parts of this book to be most inspiring and many of the latest developments are covered, including dark energy, inflation, gravitational waves, extra dimensions and quantum gravity. I believe that a “popular” audience will enjoy this; I know my friends will. With only 189 pages, the book is pleasantly concise, although

it is a little uneven. I think that sometimes too much is assumed or that things are not explained explicitly enough. A good editor could probably push it that extra step, to make it an even better book.

(This book was first published in German as *Vom Universum zu den Elementarteilchen. Eine erste Einführung in die Kosmologie und die fundamentalen Wechselwirkungen*, Springer 2011.)

● Herbert Dreiner, University of Bonn.

Books received

Scientific Writing 2.0: A Reader and Writer's Guide

By Jean-Luc LeBrun

World Scientific

Hardback: £51

Paperback: £23

E-book: £67

This guide aims to help scientists write papers for scientific journals. Using the key parts of typical scientific papers (title, abstract, introduction, visuals, structure and conclusions), it shows through numerous examples how to achieve the essential qualities required in scientific

writing. To enable writers to assess their writing from a reader's perspective, it also offers practical metrics in the form of six checklists, as well as an original Java application to assist in the evaluation.

Hamiltonian Mechanics of Gauge Systems

By Lev V Prokhorov and Sergei V Shabanov

Cambridge University Press

Hardback: £80 \$130

E-book: \$104

This book provides a systematic introduction to the Hamiltonian mechanics of systems with gauge symmetry and reveals how gauge symmetry may lead to a non-trivial geometry of the physical phase space and studies its effect on quantum dynamics using path-integral methods. It covers aspects of Hamiltonian path-integral formalism in detail, together with a number of related topics, such as the theory of canonical transformations on phase space supermanifolds, non-commutativity of canonical quantization and elimination of non-physical variables. The discussion is accompanied by detailed examples of dynamical models with gauge symmetries, clearly illustrating the key concepts.

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