

Bookshelf

COMPILED BY VIRGINIA GRECO, CERN

Images of Time: Mind, Science, Reality

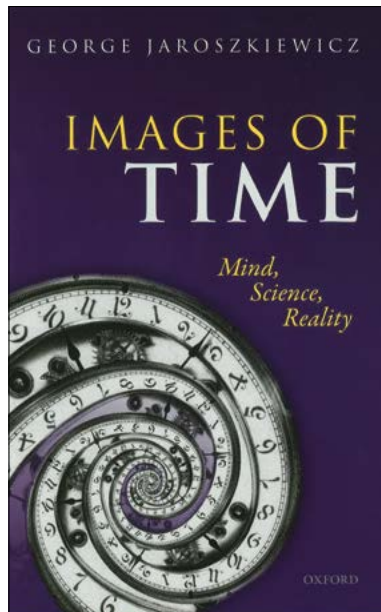
By George Jaroszkiewicz

Oxford University Press

For ages, sundials have been used to measure time, with typical accuracies in the order of a few minutes. After Galileo discovered that the small oscillations of a pendulum are isochronous, Huygens built the first prototype of a pendulum clock reaching the remarkable accuracy of a few seconds. Today, improved measurements of time and frequency are at the heart of quantum electrodynamics (QED) precision tests. The anomalous magnetic moment of the muon is measured with an accuracy of more than one part in a billion. The global-positioning system (GPS) and satellite communications, as well as other technological applications, are based (directly or indirectly) on accurate measurements of time.

There are some who argue that, while time is measured accurately, its nature is debatable in so far as it appears ubiquitously in physics (from the second law of thermodynamics to the early universe) but often with slightly different meanings. There are even some who claim that time is a mystery whose foundations are sociological, biological and psychological. This recent work by George Jaroszkiewicz suggests that different disciplines (or even different areas of physics) elaborated diverse images of time through the years. The ambitious and erudite purpose of the book is to collect all of the imageries related to the conceptualisation of time, with particular attention to the physical sciences.

The book is neither a treatise on the philosophy of science nor is it a monograph of physics. The author tries to find a balance between physical concepts and philosophical digressions, but this goal is not always achieved: various physical concepts are introduced by insisting on a mathematical apparatus that seems, at once, too detailed for the layman and too sketchy for the scholar. Through the book's 27 chapters (supplemented by assorted mathematical appendices), the reader is led to reflect on the subjective, cultural, literary, objective, and even illusionary, images of time. Each chapter consists of various short subsections, but the guiding logic of the chapter is sometimes lost in the midst of many interesting details. The overall impression is that different branches of physics deal with multiple images of time. Because



these conceptualisations are not always consistent, time is perceived by the reader (and partly presented by the author) as an enigmatic theme of speculation. A malicious reader might even infer that after nearly five centuries of Galilean method, the physicists are dealing daily with something they do not quite understand.

This knowledgeable review of the different images of time is certainly valuable, but it fails to explain why improved measurements of time and frequency are correlated with the steady development of modern science in general and of physics in particular. The truth is that physical sciences thrive from a blend of experiments, theories and enigmas: without mysteries driving our curiosity, we would not know why we should accurately measure, for instance, the anomalous magnetic moment of the muon. However, by only contemplating time as an enigma, we would probably still be stuck with sundials.

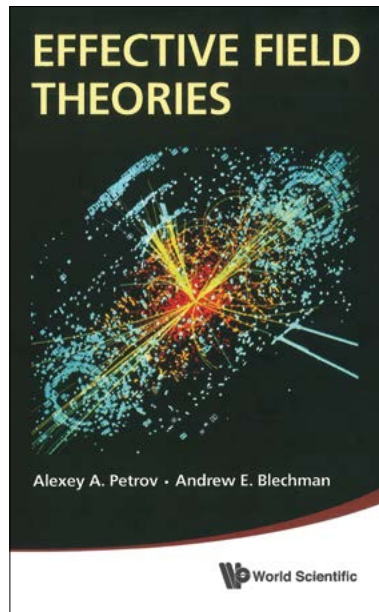
● Massimo Giovannini, CERN & INFN Milan-Bicocca.

Effective Field Theories

By Alexey A Petrov and Andrew E Blechman

World Scientific

The importance of effective field theory (EFT) techniques cannot be over-emphasised. In fact, all theories are, in some sense, effective. A book that discusses



these techniques, groups different cases in which EFTs are necessary, and provides numerous examples, is therefore necessary.

After illustrating the ubiquitousness of EFTs with a discussion of Newtonian gravity, superconductivity, and the Euler–Heisenberg theory of photon–photon scattering below the electron mass, the book splits into different directions to examine qualitatively diverse situations where EFTs are used. Fermi theory, chiral perturbation theory, heavy-quark effective theory, non-relativistic quantum electrodynamics (chromodynamics), and even the EFT for physics beyond the Standard Model, are all discussed with a common language that allows the reader to find analogies and appreciate the different physics of these fundamentally different systems.

Soft collinear effective theory (SCET) and non-relativistic general relativity provide a different context in which EFTs are useful as a computational tool. The text exploits the intuition developed in the previous examples to identify the relevant expansion parameters and to organise hierarchically the different contributions to the scattering amplitudes.

Admittedly, the book focuses on high-energy physics topics, neglecting many applications in soft and condensed matter.

The volume is very well written, it is continuous, and includes a rich introduction

on the main topics necessary to understand and use EFTs, such as symmetries, renormalization-group methods and anomalies. As an advanced quantum field theory (QFT) book, it exploits the possibility of relying on the previous knowledge of the reader and concentrates on the relevant issues; the introduction is written in a practical way, providing EFT jargon and highlighting the differences between renormalisable and non-renormalisable theories.

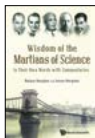
The tone of the book makes it suitable not only for practitioners in the field, but also for students looking for a broad perspective on different QFT topics – the common EFT language providing the thread – and for teachers searching for analogies and similarities between advanced and classical topics.

● *Francesco Riva, CERN.*

Books received

Wisdom of the Martians of Science: In Their Own Words with Commentaries

By Balazs Hargittai and Istvan Hargittai
World Scientific



The “Martians” of science that the titles refers to are five Jewish-Hungarian scientists who distinguished themselves for significant discoveries in fundamental science

that contributed to shaping the modern world. These great scientists are John von Neumann, a pioneer of the modern computer; Theodore von Kármán, known as the scientist behind the US Air Force; Loe Szilard, initiator of the development of nuclear weapons; Nobel laureate Eugene P Wigner, who was the world’s first nuclear engineer; and Edward Teller, colloquially known as “the father of the hydrogen bomb”.

Born to upper-middle-class Jewish families and raised in the sophisticated atmosphere of liberal Budapest, they were forced to leave their anti-Semitic homeland to emigrate to Germany, and ultimately to the US, which became their new home country, to the point that they devoted themselves to its defence.

The book comes as a follow-up to a previous title, *The Martians of Science*, which drew the profiles of these five scientists and presented their contributions to their fields of research. The aim of this second volume is to show the wisdom of the Martians by presenting their thoughts and ideas with their own words and putting them into context. Through direct quotes from the five characters and commentaries from other people who knew them, the authors offer an

insight into the thinking of such great minds, which they find instructive and entertaining. They are witty, provocative, intriguing and, as the author says, never boring.

Excitons and Cooper Pairs: Two Composite Bosons in Many-Body Physics

By Monique Combescot and Shine-Yuan Shiu
Oxford University Press



This book deals with two major but different fields of condensed-matter physics, semiconductors and superconductors, starting from the consideration that the key particles of these materials, which are excitons and Cooper pairs, are actually composite bosons. The authors are not interested in describing the physics of these materials, but in better understanding how composite bosons made of two fermions interact and, more specifically, identifying the characteristics of their fermionic components that control many-body effects at a microscopic level.

The many-body physics of elementary fermions and bosons has been largely studied using Green functions and with the help of Feynman diagrams for visualisation.

But these tools are not easily applicable to many-body physics of composite bosons made of two fermions. Consequently, a new formalism has been developed and a new type of graphic representation, the “Shiva diagrams” (so named because of the multi-arm structure reminiscent of the Hindu god Shiva) adopted.

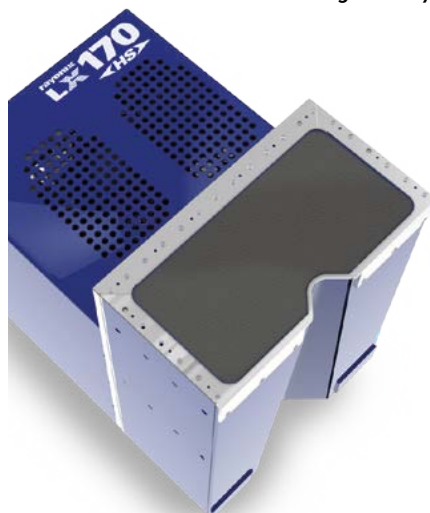
After two sections dedicated to the mathematical and physical foundation of Wannier and Frenkel excitons and of Cooper pairs, the book continues with a discussion on composite particles made of excitons. In the fourth and last part, the authors look at some aspects of the condensation of composite bosons, which they call “bosonic condensation”, and which is different from the Bose–Einstein condensation of free elementary bosons. Other important issues are discussed, such as the application of the Pauli exclusion principle on the fermionic components of bosonic particles.

Although suitable for advanced undergraduate and graduate students in physics without a specific background, this text will also appeal to researchers in condensed-matter physics who are willing to obtain insight into the many-body physics of two composite bosons. ▶

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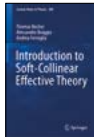
Bookshelf

Introduction to Soft-Collinear Effective Theory

By Thomas Becher, Alessandro Broggio and Andrea Ferroglia

Springer

Also available at the CERN bookshop



The volume provides an essential and pedagogical introduction to soft-collinear effective field theory (SCET), one of the low-energy effective field theories (EFTs) of the Standard Model developed in the last two decades. EFTs are used when the problem that is tackled requires a separation of the low-energy contributions from the high-energy part, to be solved.

SCET has already been applied to a large variety of processes, from B-meson decays to jet production at the LHC. As a consequence, the need was felt for a self-contained text that could make this subject easily accessible to students, as well as to researchers who are not experts in the subject. Nevertheless, a background in quantum field theories and perturbative QCD is a prerequisite for the book.

The basics of the construction of effective theory are presented in detail. The expansion of Feynman diagrams describing the production of energetic particles is described, followed by the construction of an effective Lagrangian, which produces the different terms that contribute to the expanded diagrams. The case of a scalar theory is considered first, then the construction is extended to the more complex case of QCD.

To show the method at work, the authors have included some collider-physics example applications (the field where, in the last few years, SCET has been applied the most). In particular, the soft-gluon resummation for the inclusive Drell–Yan cross-section in proton–proton collisions is discussed, and SCET formalism is used to perform transverse-momentum resummation. In addition, the application of SCET methods to a process with high energetic particles in many directions is analysed, and the structure of infrared singularities in n-point gauge-theory amplitudes derived.

Quark–Gluon Plasma 5

By Xin-Nian Wang (ed.)

World Scientific



As the fifth volume in a series on quark–gluon plasma (QGS), this text provides an update on the recent advances in theoretical and phenomenological studies

of QGS. Quark–gluon plasma (also informally called “quark soup”) is a state of matter in quantum chromodynamics (QCD) hypothesised to exist at extremely high temperatures and densities, in which the constituents of hadrons, i.e. quarks and gluons, are in a special condition of high freedom.

The book is a collection of articles written by major international experts in the field, with the aim to meet the needs of both novices – thanks to its pedagogical and comprehensive approach – and experienced researchers.

A significant amount of space is given – of course – to the impressive progress in experimental and theoretical studies of new forms of matter in high-energy heavy-ion collisions at RHIC, as well as at the LHC. The strong coupled quark–gluon plasma (sQGP) discovered at RHIC has attracted the attention of many researchers and defined the path for future studies in the field. At the same time, the heavy-ion collisions at unprecedented high energies at the LHC have opened up new lines of research.

This updated and detailed overview of QGS joins the previous four volumes in the series, which altogether present a comprehensive and essential review of the subject, both for beginners and experts.

The Composite Nambu–Goldstone Higgs

By Giuliano Panico and Andrea Wulzer

Springer



This book provides a description of a composite Higgs scenario as possible extension of the Standard Model (SM). The SM is, by now, the established theory of electroweak and strong interactions, but it is not the fundamental theory of nature. It is just an effective theory, an approximation of a more fundamental theory, which is able to describe nature under specific conditions.

There are a number of open theoretical issues, such as: the existence of gravity, for which no complete high-energy description is available; the neutrino masses and oscillation; and the hierarchy problem associated with the Higgs boson mass (why does the Higgs boson have so small a mass? Or, in other words, why is it so much lighter than the Planck mass?).

Among the possible solutions to the hierarchy problem, the scenario of a composite Higgs boson is a quite simple idea that offers a plausible description of the experimental data. In this picture, the Higgs must be a (pseudo-) Nambu–Goldstone boson, as explained in the text.

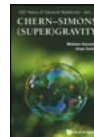
The aim of this volume is to describe the composite Higgs scenario, to assess its likelihood of being a model that is actually realisable in nature – to the best of present-day theoretical and experimental understanding – and identify possible experimental manifestations of this scenario (which would influence future research directions). The tools employed for formulation of the theory and for the study of its implications are also discussed.

Thanks to the pedagogical nature of the text, this book could be useful for graduate students and non-specialist researchers in particle, nuclear and gravitational physics.

Chern–Simons (Super) Gravity – 100 Years of General Relativity (vol. 2)

By Mokhtar Hassaine and Jorge Zanelli

World Scientific



Written on the basis of a set of lecture notes, this book provides a concise introduction to Chern–Simons (super) gravity theories accessible to graduate students and researchers in physics and mathematics.

Chern–Simons (CS) theories are gauge-invariant models that could include gravity in a consistent way. As a consequence, they are very interesting to study because they can open up the way to a common description of the four fundamental interactions of nature.

As is well known, three such interactions are described by the Standard Model as Yang–Mills (YM) theories, which are based on the principle of gauge invariance (requiring a correlation between particles at different locations in space–time). The particular form of these YM interactions makes them consistent with quantum mechanics.

On the other hand, gravitation – the fourth fundamental force – is described by general relativity (GR), which is also based on a gauge principle, but cannot be quantised following the same steps that work in the YM case.

Gauge principles suggest that a viable path is the introduction of a peculiar, yet generic, modification of GR, consisting in the addition of a CS term to the action.

Besides being mathematically elegant, CS theories have a set of properties that make them intriguing and promising: they are gauge-invariant, scale-invariant and background-independent; they have no dimensionful coupling constants; and all constants in the Lagrangian equation are fixed rational coefficients that cannot be adjusted without destroying the gauge invariance.



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