

BOOKSHELF

BOOK OF THE MONTH

Selected Papers of Richard Feynman (with commentary), edited by Laurie M Brown, World Scientific Series in 20th Century Physics, Vol. 27, ISBN 981 02 4130 5 hbk ISBN 981 02 4131 3 pbk.

After *A Quantum Legacy*, the selected papers of Julian Schwinger (edited by Milton, December 2000 p44), it is fitting that the next volume in this carefully selected series covers the work of Richard Feynman.

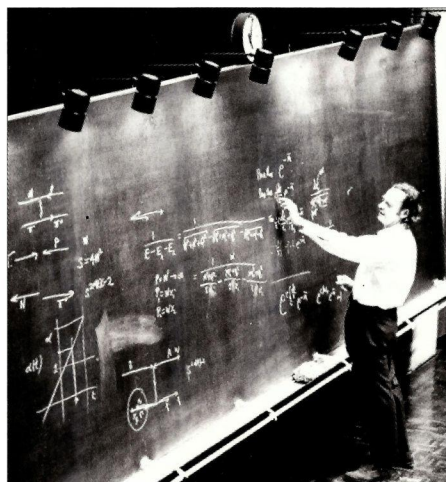
Now a cult figure, Feynman is fast becoming one of the most prolifically documented physicists of the past century. As well as his own popular work (*You Must Be Joking, What Do You Care What Other People Think?*) and his various lectures, there are biographies or biographical material by Gleick, Brown and Rigden, Mehra, Schweber, Sykes, and Gribbin and Gribbin.

Anecdotes about such a flamboyant character are easy to find, but the man's reputation ultimately rests on his major contributions to science, which this book amply documents. Chapters, of various lengths, deal with his work in quantum chemistry, classical and quantum electrodynamics, path integrals and operator calculus, liquid helium, the physics of elementary particles, quantum gravity and computer theory. Each has its own commentary.

As a foretaste of things to come, the first chapter serves up just a single paper – "Forces in molecules" – written by Feynman at the age of 21, in his final year as an undergraduate at MIT. This result – the Hellmann–Feynman theorem – has played an important role in theoretical chemistry and condensed matter physics.

Chapter 2 begins with Feynman's 1965 Nobel Lecture, goes on to include work with John Wheeler at Princeton, which explored the underlying assumptions about the interaction of radiation and matter, and concludes with the classic 1949 papers that presented his revolutionary approach to quantum electrodynamics.

The Nobel Lecture alone is worth reading – clearly a major early source of Feynman anecdote, such as the Slotnick episode. One is struck by Feynman's ambivalent attitudes – his enormous regard for father figures such as Wheeler and Bethe on the one hand, and his clear disdain for many contemporaries on the



Richard Feynman at CERN in 1965.

other. Another good read in this chapter is Feynman's paper presented at the 1961 Solvay meeting, and the ensuing discussion.

Chapter 3 deals with the detailed presentation of the path integral approach, which enabled Feynman to dissect electrodynamics and look at it from a fresh, uncluttered viewpoint.

From 1953 to 1958, Feynman looked for fresh pasture and produced a series of seminal papers on the atomic theory of superfluid helium, which is presented in Chapter 4.

Chapter 5 is split into two parts. The first, on weak interactions, includes the classic 1957 paper with Gell-Mann and some lecture notes from the 1960s exploring the consequences of SU3 symmetry for weak interactions. The second part – by far the largest section of the book – deals with his approach to partons, quarks and gluons. Feynman began thinking about describing hadrons simply as an assembly of smaller parts – his partons – just when experiments were beginning to probe this inner structure. This is a good example of how Feynman, arriving at a fresh interest, would invariably strip problems down to their essential parts before reassembling them in a way that he, and many other people too, understood better.

Feynman's interest in numerical computation went back to his time at Los Alamos, when he had to model the behaviour of explosions using only the mechanical calculators of the time. Coming back to the subject in the 1980s, he went on to pioneer the idea of quantum computers. Apart from the prophetic papers published here, this aspect of his work has been well documented

in *The Feynman Lectures on Computing* (ed. A J G Hey and R W Allen, Perseus).

Selected Papers of Richard Feynman concludes with a full bibliography. Even without the burgeoning Feynman cult, such a selection of key papers is a useful reference. However, with almost 1000 pages, the book could perhaps have been better signposted. The selected papers are not listed in the initial contents and the pages have no running heads to indicate how the chapters fall. Gordon Fraser, CERN.

Calorimetry: Energy Measurement in Particle Physics by Richard Wigmans, Oxford University Press, ISBN 019 850296 6, 726pp, £85.

The role of calorimetry in high-energy physics has become increasingly important during the last 20 years. This is due to the increase in energy of the particle beams available at the major accelerators and to the need for hermetic detectors. The 1980s, in particular the second half of the decade, saw an important breakthrough in the understanding of the mechanisms underlying the development of hadronic cascades and their energy loss.

The theme around which this breakthrough took place is "compensation": for a compensating calorimeter $e/h = 1$, where e represents the response to an electromagnetic and h the response to a non-electromagnetic, that is purely hadronic, shower of the same energy. For compensating calorimeters the energy measurement of electrons and hadrons of the same energy yields the same average response for all energies, at the same time leading to optimal hadronic energy resolution. It is also a prerequisite for linearity of the hadronic energy measurement.

In practice, very few compensating calorimeters have been built for major experiments (one example is the calorimeter of the ZEUS experiment at HERA, discussed in the book), probably because, in practice, achieving compensation means making a concession to the electromagnetic energy resolution. None of the experiments planned at the Large Hadron Collider, for example, will employ a compensating calorimeter. The importance of the research into compensation is nevertheless very large in that it led to a much better understanding of calorimetry in general. The author of the book

has made original and essential contributions to this field through his own research.

The book reflects the deep and encyclopedic knowledge that the author has of the subject. This makes the book a rich source of information that will be useful for those designing calorimeters and for those analysing calorimeter data, for a long time to come. At the same time the book is not always successful in finding a way of organizing and conveying all of this knowledge in a clearly structured and efficient way. Parts of the book are rather narrative and long-winded.

The most important chapters are those on Shower Development, Energy Response, Fluctuations and Calibration. Also, that on Instrumental Aspects contains essential information. The chapters on generic studies and on existing (or meanwhile dismantled) and planned calorimeter systems, are interesting but less necessary parts of a textbook. Moreover, the author does not always keep to the subject – calorimetry – leading to unnecessary excursions and, what is worse, outdated material. It would, on the other hand, be interesting if the author, in his description of the calorimeters under construction for the Atlas experiment, had been a bit more explicit on what, in the light of the ideas developed earlier in the book, the optimal approach would be to (inter)calibrating this very complex calorimeter system. The chapter on Calibration is probably the most essential part of the book, bringing together many of the fundamental issues on shower development, signal generation and detection. Reading this chapter, one gets the impression that in fact it is impossible to calibrate calorimeters, but the style chosen by the author is only to

In practice, achieving compensation means making a concession to the electromagnetic energy resolution.

emphasize that the issue is subtle and great care must be taken. The chapter contains information that is extremely worthy of consideration, culminating in the recommendation that, in the case of non-compensating calorimeters, individual (longitudinal) calorimeter sections should be

calibrated by the same particles generating fully contained showers in each section, a recommendation that, in practice, cannot always be satisfied. In his ardour to emphasize the importance of the (inter)calibration of longitudinal calorimeter segments, the author even invokes decays, such as that of the neutral rho into two neutral pions, that do not exist in nature – we get the point and forgive him. It is, however, true that there are more places where the book would have profited from a critical, final edit.

Calorimetry is a book that describes the essential physics of calorimetry. It also contains a wealth of information and practical advice. It is written by a leading expert in the field. The fact that the discussions sometimes do not follow the shortest path to the conclusion and that perhaps the “textbook part” of this work should have been accommodated in a separate volume does not make the book less important: it will be amply used by those trying to familiarize themselves with calorimetry and in particular by those analysing the data of the very complex calorimeter systems of future experiments, such as at LHC.

Jos Engelen, NIKHEF, University of Amsterdam.

Quarks and Gluons: a Century of Particle Charges by M Y Han (Duke), World Scientific Publishing, 168pp, ISBN 981 02 3704 9 hbk \$34/£21, ISBN 981 02 3745 6 pbk) \$16/£10.

This is a readable little book on particle physics and is aimed at those with no previous exposure to the subject. It starts with the discovery of the electron in 1897 and works its way more or less historically up to the present. That means, of course, that it contains a lot about leptons and photons as well as the quarks and gluons of the title.

The guiding theme is the discovery of different kinds of conserved charges – first electric charge, then baryon number and the lepton numbers, and finally the more subtle kind of charges that are the source of the colour force between the quarks.

Like Stephen Hawking, the author manages to avoid all equations, except $E = mc^2$. The style is chatty and colloquial (American), which will have some non-native English readers running for their phrase books. For example, correct predictions are “right on the money”, and when the terminology seems comical the reader is exhorted to “get a grip on yourself”. Nevertheless, as one would

expect from a leading contributor to the field, Han takes care to get things right even when using simple language, as for example in his discussion of spin.

The jacket says that the book will be “both accessible to the layperson and of value to the expert”. I imagine that the latter refers to its value in helping us to communicate with non-experts.

Like Stephen Hawking, the author manages to avoid all equations, except $E = mc^2$.

I have some misgivings about this book, mainly because its insistence on discussing only those charges that are (within current limits) absolutely conserved leaves the reader with the impression that nothing much is understood about the weak interaction. The author even says that the weak charges have yet to be identified. All of the beautiful developments of electroweak unification are omitted. Also, there is no mention of the exciting possibilities that lie in the near future. This makes the subject seem a bit moribund and musty. For example, we are told that the discovery of the pion in 1947 was “one of the last hurrahs” of cosmic-ray physics, whereas in fact that field continues to show astonishing vitality, with neutrino studies, ultrahigh-energy primaries and other fascinating phenomena promising a rich future.

Bryan Webber, Cambridge.

Anomalies in Quantum Field Theory by R A Bertlmann, Oxford University Press, ISBN 01 850762 3, pbk £29.95.

Field theory “anomalies” constitute a long-standing source of physics and mathematics. They have remained fascinating for physicists and mathematicians, as ongoing developments in string and brane theory show.

This book gives a comprehensive description of the many facets of this subject that were known before the mid-1980s. It is essentially self-contained and thus deserves to be called a textbook. Both mathematicians and physicists can learn from this volume.

With a modest knowledge of quantum mechanics, a mathematician can read about the history of the subject: the puzzle of the decay of the neutral pion into two gamma-ray photons; the inconsistencies of the perturbative treatment of gauge theories

related to the occurrence of anomalies; the original Feynman graph calculations; and the theoretical constructions that introduced relationships with topology, up to the elementary versions of the index theorem for families.

The physicist will find all of the necessary equipment in elementary topology and differential geometry combined in constructions that are familiar to professional mathematicians. S/he will find thorough descriptions of the algebraic aspects that emerged from perturbation theory, both in the case of gauge theories and in the case of gravity, and an introduction to the way in which they tie up with index theory for elliptic operators and families thereof.

The book reads fluently and is written so clearly that one not only gets an overview of the subject, but also can learn it at an elementary level.

The bibliography is a rather faithful reflection of the physics literature and includes a few basic mathematical references, which give the reader the opportunity to learn more in whichever

With a modest knowledge of quantum mechanics, a mathematician can read about the history of the subject.

direction s/he chooses.

As mentioned, the subject is still developing in the direction of new mathematics and, possibly, new physics in the context of strings and branes. One may therefore regret that the book stops around the developments that took place in the mid-1980s.

The book is already more than 500 pages. Since it is essentially self-contained and every topic that is dealt with is described in sufficient detail to allow a non-specialist to get acquainted with it, at least at an elementary level, the mathematical techniques do not go beyond elements of differential geometry, as well as of homology, cohomology and homotopy theory. Generalized cohomology theories, including K-theory, only appear in a phenomenological

disguise, in connection with the description of the index theorem for families, in the particular case relevant to gauge theories, but not as mathematical prerequisites.

As a consequence of the principle of maximal perversity, one may expect that physics will exhibit subtle effects describable in terms of the above-mentioned constructions. In such an event, there remains the hope for a corresponding textbook as understandable as this one, possibly written by the same author.

Raymond Stora, LAPP, Annecy.

A Modern Introduction to Particle Physics

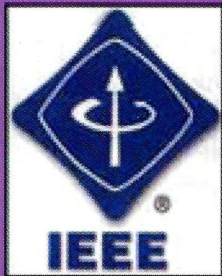
by Fayyazuddin and Riazuddin, 2nd edn, World Scientific ISBN 9810238762 hbk, ISBN 9810238770 pbk.

The first edition of this book by the talented twins from Pakistan, which appeared in 1992, has been updated, with the chapters on neutrino physics, particle mixing and CP violation, and weak decays of heavy flavours having been rewritten. Heavy quark effective field theory and introductory material on supersymmetry and strings are also included.

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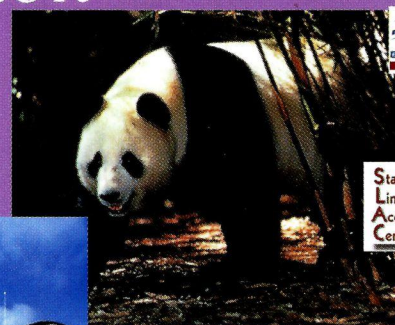
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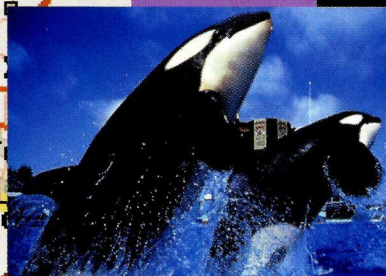
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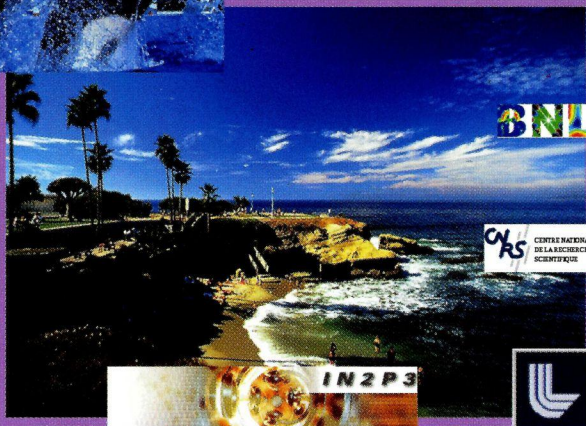
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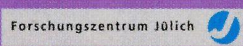
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