

BOOKSHELF

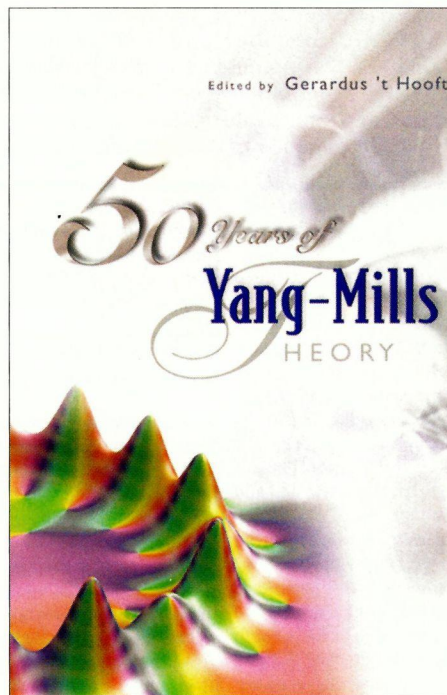
50 Years of Yang–Mills Theory by Gerardus 't Hooft (ed), World Scientific. Hardback ISBN 9812389342, £51 (\$84). Paperback ISBN 9812560076, £21 (\$34).

Anniversary volumes usually mark a significant birthday of an individual, or perhaps an institution. But this fascinating compilation celebrates the golden jubilee of a theory – namely, the type of non-Abelian quantum gauge field theory first published by Chen Ning Yang and Robert L Mills in 1954, and now established as a central concept in the Standard Model of particle physics. It was a brilliant idea (by the editor, Gerardus 't Hooft, I assume) to signal the 50th birthday of Yang–Mills theory by gathering together a wide range of articles by leading experts on many aspects of the subject. The result is a most handsome tribute of both historical and current interest, and a substantial addition to the existing literature.

There are 19 contributions, only two of which have been published elsewhere. They are grouped into 16 sections (“Quantizing Gauge Fields”, “Ghosts for Physicists”, “Renormalization” and so on), each accompanied by brief but illuminating comments from the editor. The style of the contributions ranges from an equation-free essay by Frank Wilczek, to a paper by Raymond Stora on gauge-fixing and Koszul complexes. Somewhere in between lie, for example, François Englert’s review of “Breaking the Symmetry”, and Stephen Adler’s exemplary account of “Anomalies to All Orders”.

One recurrent theme is how unfashionable quantum field theory was in the 1950s and 1960s. As 't Hooft puts it: “In 1954, most of those investigators who did still adhere to quantum field theory were either stubborn, or ignorant, or both. In 1967 Faddeev and Popov not only had difficulties getting their work published in Western journals; they found it equally difficult to get their work published in the USSR, because of Landau’s ban on quantized field theories in the leading Soviet journals.” One of the most interesting papers in the book is the 1972 English translation of their 1967 “Kiev Report”, produced via an initiative of Martinus Veltman and Benjamin Lee. It is more detailed than their famous 1967 paper in *Physics Letters*, and includes a discussion of the gravitational field.

Alvaro De Rújula inimitably brings to life the strong interactions between theorists and experimentalists in the heady days of



1973–1978. He includes a candid snap of Howard Georgi and Sheldon Glashow, circa 1975, which made me wish there were more such shots of the leading players from that era. De Rújula’s is the only contribution to address the experimental situation, despite the editor’s admission that the lasting impact of Yang–Mills theory depended on “numerous meticulous experimental tests and searches”. But, after all, this is a volume celebrating the birthday of a theory.

Many contributors look to the future, as well as the past. These include Alexander Polyakov on “Confinement and Liberation”, Peter Hasenfratz on “Chiral Symmetry and the Lattice”, and Edward Witten on “Gauge/String Duality for Weak Coupling”.

I have only had space enough to (I hope) whet the reader’s appetite. This unusual and elegant *festschrift* is a treat for theorists – and, as a bonus, you get a full-colour representation on the cover of a 17-instanton solution of the Yang–Mills field equations (designed by the editor).

Ian Aitchison, Oxford University.

High p_T Physics at Hadron Colliders by Dan Green, Cambridge University Press. Hardback ISBN 0521835097, £70 (\$110).

Over the past several years, Fermilab physicist Dan Green has developed an excellent course on “High p_T Hadron Collider

Physics”. This is now published as a Cambridge monograph that successfully traces the important past and future roles of hadron colliders in testing and probing the limits of the Standard Model for electroweak and strong interactions. In so doing, it provides an accessible and pedagogic introduction to key features of parton–parton collisions in pp or $p\bar{p}$ interactions. It is not, however, an up-to-date survey of the field. Rather, the centrepiece of Green’s book concerns the motivation and experimental strategy for detecting, and subsequently studying, the Higgs scalar particle (the last undetected element of the minimal Standard Model).

Written by an experimentalist, the book is qualitative in nature and can even be enjoyed by final-year undergraduates, although to profit from it formal introductions to particle-physics phenomenology and quantum field theory are essential. (Such courses are fortunately part of most relevant Master’s programmes, and the reader is directed to excellent texts on the subject.) A key feature is the use of dimensional (heuristic) arguments to estimate key production and decay processes in hadron collisions. In addition, and uniquely, the COMPHEP freeware program has been extensively used to back up the dimensional arguments with lowest order computations. Despite some incompatibilities of nomenclature, this innovation is (to the reviewer) extremely successful.

The first chapter presents a concise summary of the Standard Model particles and their couplings, as well as a description of the Higgs mechanism for mass generation of the W and Z bosons. It lays out the key properties of the Higgs boson, and concludes with a list of issues that are not answered by the Standard Model. These issues are (rather superficially) discussed in chapter six, with chapters two to five directed towards experimental and phenomenological issues relevant to the Higgs search.

Chapter two describes, in an extremely accessible way, the detector requirements for identifying key high- p_T parton–parton collision processes and the associated instrumental or irreducible physics-related backgrounds. The treatment of jet energy reconstruction and di-jet mass reconstruction is excellent. Inevitably, given the author’s background in the D0 and CMS experiments at Fermilab, the book leans towards examples of these experiments. In a few cases, some important

instrumental innovations are not given adequate space (e.g. the real-time selection of heavy quarks as in the CDF experiment). Students could also have benefited from a description of the relative merits of the CDF and D0 experiments, and of course of the future ATLAS and CMS detectors at CERN's Large Hadron Collider (LHC).

The third chapter is good reading for any new graduate student. Green introduces key features of collider physics: the central rapidity plateau and its energy dependence; the basic parton-parton collision processes and their kinematics; the main gauge boson and gauge-boson pair production processes; and jet fragmentation. In all cases experimental data (usually not the latest) are used to justify heuristic arguments and COMPHEP calculations. A series of exercises complements the chapter.

Chapters four and five concentrate respectively on the more important results from Fermilab's Tevatron and on the Higgs search strategy at the LHC experiments (for which chapter four's material is invaluable as a guide to the experimental backgrounds to be expected from any Higgs signal at the LHC). As a reviewer, I enjoyed the experimental approach of these two chapters and their highly readable nature. However, the extremely important sections on heavy-quark (b and t quark) production were rather incomplete, given the unique measurements at the Tevatron and the important implications for the LHC. While the somewhat arbitrary choice of figures in chapter four (taken in most cases from the experiments) is adequate for lecture notes, it detracts from the book's quality that an effort was not made to include the latest available data, and to combine data from the CDF and D0 experiments. Chapter five concerns the experimental strategy for detecting and studying the Standard Model Higgs particle at the LHC, and relies heavily on relevant preparatory studies from the ATLAS and CMS experiments.

Finally, the concluding sixth chapter discusses extensions to the Standard Model

such as supersymmetry, as well as some of the open questions alluded to in chapter one. While extensions relevant to the LHC physics programme must be discussed, it felt as if this was a hurried addition. Judy Garland's quotation, from *The Wizard of Oz*: "Toto, I've a feeling we're not in Kansas anymore," is rather appropriate.

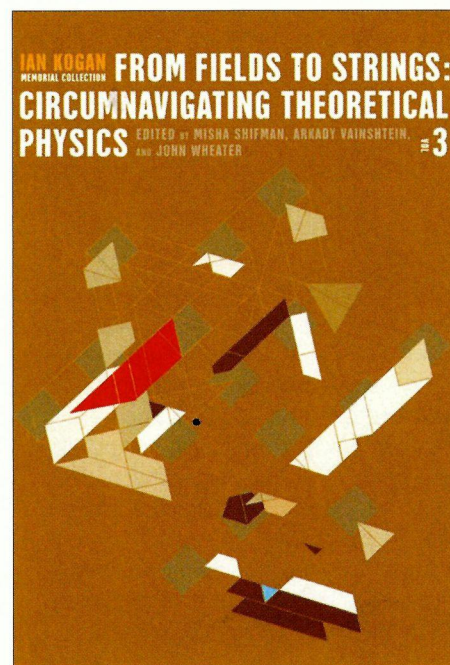
Published at a time when the CDF and D0 experiments are increasing their data samples by more than an order of magnitude, and in advance of the LHC, Green's book has limited shelf life in its present edition. However, despite some shortcomings, its core is an excellent introduction for any graduate student starting out in experimental hadron-collider physics and can be strongly recommended. Dan Green should be congratulated on the overall quality of his text. Presumably, any new edition beyond 2007 will provide some interesting updates.

Allan Clark, University of Geneva.

From Fields to Strings: Circumnavigating Theoretical Physics (Ian Kogan Memorial Collection) by Misha Shifman, Arkady Vainshtein and John Wheeler (eds), World Scientific. Hardback ISBN 9812389555 (three volume set), £146 (\$240).

On the morning of 6 June 2003, Ian Kogan's heart stopped beating. It was the untimely departure of an outstanding physicist and a warm human being. Ian had an eclectic knowledge of theoretical physics, as one can easily appraise by perusing the list of his publications at the end of the third volume of this memorial collection.

The editors of these three volumes had an excellent idea: the best tribute that could be offered to Ian's memory was a snapshot of theoretical physics as he left it. The response of the community was overwhelming. The submitted articles and reviews provide a thorough overview of the subjects of current interest in theoretical high-energy physics and all its neighbouring subjects, including mathematics, condensed-matter physics, astrophysics and cosmology. Other subjects



of Ian's interest, not related to physics, will have to be left to a separate collection.

The series starts with some personal recollections from Ian's family and close friends. It then develops into a closely knit tapestry of subjects including, among many other things, quantum chromodynamics, general field theory, condensed-matter physics, the quantum-hole effect, the state of unification of the fundamental forces, extra dimensions, string theory, black holes, cosmology and plenty of "unorthodox physics" the way Ian liked.

These books provide a good place to become acquainted with many of the new ideas and methods used recently in theoretical physics. It is also a great document for future historians to understand, first hand, what physicists thought of their subject at the turn of the 21st century. There is much to learn and profit from this trilogy. Circumnavigating theoretical physics is indeed fun. It is unfortunate, however, that it had to be gathered in such sad circumstances.

Luis Alvarez-Gaume, CERN.



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