nent in this construction can be challenged. There is no real evidence that Grassi was the author of G3; the handwriting samples reproduced in the book do not support the claim, nor is there any other halfway convincing argument. Atomism is only a quite minor theme in *The Assayer*; in no sense can that work be construed as a defense of it. Galileo took over a view that had become widespread among natural philosophers and used it for his own purposes without any particular emphasis. There is not the slightest evidence that this issue was ever so much as *mentioned* in the course of the debates that followed the appearance of the *Dialogue*. The evidence that the Pope was violently angry with Galileo is overwhelming. Far from attempting to protect the scientist, the Pope's evident feeling of betrayal led him to carry on the vendetta against his former friend even into Galileo's last years at Arcetri, and indeed even beyond the grave.

The likely reasons have often been laid out. Galileo had promised to treat Copernicanism "hypothetically," that is, as a calculational fiction. (This was how Urban used the term "hypothetical.") But the *Dialogue* claimed that the offending doctrine could be *proved*. The issue was no "venial crime." It was not a matter of astronomy nor of displacing man from the center of the universe. It was a matter of the authority of Scripture, in an age where this issue (even more than the Eucharistic doctrine) was at the foreground of theological debate between Protestant and Catholic. There is no evidence that the charge against Galileo was seen as the lesser of two alternatives, none that Galileo was satisfied with the outcome, nor any that di Guevara and Grassi were "exiled" because of their roles in the affair.

In short, we have here an engaging "theater of shadows" to match the Rome that Redondi so eloquently invokes. The book is an altogether impressive example of what sheer erudition and a powerful historical imagination can do to transform shadow into highly readable substance.

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Introductory Nuclear Physics

Kenneth S. Krane
Wiley, New York, 1987. 845 pp. $54.90 hc ISBN 0-471-80553-X

In the past decade and a half, many new nuclear phenomena have been observed. In addition, nuclear physics is now increasingly relevant to astrophysics, the recent naked-eye supernova being only the most strikingly obvious example. Nuclear experimental techniques have also been adapted to solve problems in medicine and other disciplines. Someone teaching the subject would surely like to address many of these issues within an introductory undergraduate nuclear physics course. Until recently, however, the only available texts were ones written in the late 1960s or early 1970s and few have been revised since. New texts are clearly needed. *Introductory Nuclear Physics* by Kenneth Krane is a welcome addition to the literature; it discusses many of the new phenomena and has many attractive features that lead me to strongly recommend it for an undergraduate course.

The book is divided into four sections, covering nuclear structure, radioactive decay, nuclear reactions, and advanced topics and applications. The section devoted to nuclear structure discusses the nucleon–nucleon interaction, the masses and radii of stable nuclei, and the shell and collective model descriptions of the low-lying nuclear levels. The section on radioactivity deals with weak, strong and electromagnetic decay modes of the nucleus; it also contains a chapter on detection techniques. In the section on nuclear reactions, there are separate chapters on accelerators, fusion and fission. The latter two chapters include descriptions of solar fusion, nuclear reactors and nuclear weapons. The final section, on advanced topics and applications, includes chapters devoted to meson physics, particle physics, nuclear astrophysics, and applications of nuclear physics to other disciplines such as medicine.

The text emphasizes experimental observations, not the formal development of nuclear theory. In most cases, theoretical concepts are discussed at a level comparable to that of Walter Meyerhof's undergraduate text *Elements of Nuclear Physics* (McGraw–Hill, New York, 1967), but sometimes at a simpler level than found in Bernard Cohen's text *Concepts of Nuclear Physics* (McGraw–Hill, New York, 1971) or in W. E. Burcham's text *Elements of Nuclear Physics* (Longman, London, 1979). Formulas that require a nontrivial understanding of the quantum theories of angular momentum or many-body systems are usually motivated by simple and often classical arguments. Even in this simplified approach, some prior familarity with three-dimensional quantum mechanics is necessary, and a review chapter on the subject is included in the text. Beginning students will find the resulting text easy to read. Despite the book's considerable length (about 800 pages), an instructor can construct even a short, 10-week introductory course using this text, without a loss in continuity.

I recommend this text strongly. It covers an impressively large scope of topics and includes a number of interesting recent developments in nuclear physics and related topics. For example, spontaneous C^{14} emission, the natural fission reactor in Gabon in Africa, rotational backbending, hypernuclei, *CP* violation and grand unification theories are all briefly discussed. Krane has also taken special efforts to illustrate even the more traditional topics, such as β decay, with examples from the recent literature and to relate these measurements to issues beyond the domain of nuclear physics. With respect to β decay, for example, one finds discussions of β-delayed nucleon emission; experimental measurements of double β decay and their relationship to lepton number conservation; recent neutrino mass measurements and their relationships to the closure of the universe, lepton number mixing and the solar neutrino problem; and also a discussion of the measurement of the solar neutrino flux by Raymond Davis. As other examples, the chapter on electromagnetic decay contains a description of measurements of the gravitational redshift via the Mössbauer effect, and the chapter on neutron-induced reactions contains descriptions of the low-energy neutron interference measurements that demonstrated the phase shift of the neutron wavefunction caused by the gravitational potential. These and other inclusions of modern topics and examples really help interest the student and communicate the liveliness of the scientific endeavor.

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Collider Physics

Vernon D. Barger and Roger J. N. Phillips
Addison–Wesley, Redwood City, Calif., 1987. 592 pp. $44.95 hc ISBN 0-201-05876-6

A major achievement by particle physicists in recent years is the discovery that the strong, weak and electromagnetic forces can be described by gauge theories in what has come to be known as the "standard model." *Collider Physics* covers the application of the standard model to current and foreseen colliding-beam experiments. Colliding-beam experiments currently running or under construction include detectors at electron–positron, proton–antiproton and electron–proton machines. Such experiments dominate the frontiers of particle physics research. Colliders provide a rich arena for tests of the standard model's predictions, and lead modern particle physics research in terms of apparatus size, collaboration size and the variety of interesting and unexpected results.

With the advent in the last few years of the standard model, particle physics research has matured. The model provides a coherent framework for understanding all experimental results in the field, including results from collider experiments. Because such a broad body of data is described by the standard framework, future extensions of this picture will encompass the present standard model. It is widely felt by theorists and experimenters alike that the standard model will eventually be found to be incomplete—but not wrong. Thus, in spite of the fact that important new collider experiments are scheduled for start-up over the next few years, the material covered in this book will remain the basis for future activity in the field.

Vernon D. Barger, director of the Institute for Elementary Particle Physics at the University of Wisconsin, and Roger J. N. Phillips, head of the theoretical high-energy physics group at Rutherford–Appleton Laboratory, have both been active researchers in the development of the standard model and its phenomenology. They have contributed a wide variety of calculations, including comparison of the model's predictions to the various collider experiment results.

The extensive experience of Barger and Phillips is reflected in the breadth of coverage provided by *Collider Physics*. Nearly all aspects of the applications of the standard model to collider experiments are mentioned, most in great detail. Theoretical motivations for extensions of the standard model are also discussed, including supersymmetric models, grand unified theories, and additional families of quarks and leptons. The detailed treatment of the phenomenological implications for present and planned collider experiments of such model extensions, and of the standard model itself, provides a useful body of reference material for workers in the field. Extensive footnotes and references to the original literature are not provided in the text, but a convenient bibliography at the end of the book breaks down a list of general references by chapter. While the standard model has been a popular subject for many recent books, no other book to date combines with such breadth of coverage both the theoretical motivation and results and the relevant experimental phenomenology.

For this reason, *Collider Physics* makes an excellent reference source for experimenters and theorists alike. Problems of varying degrees of difficulty are scattered throughout. Beginning students, and others unfamiliar with the basic concepts of the field, will need supplemental information from the literature to aid them in understanding some of the discussions. But the book is a suitable text for an advanced graduate course on the subject.

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Gauge Field Theories

Stefan Pokorski
Cambridge U. P., New York, 1987. 394 pp. $89.50 hc
ISBN 0-521-26537-1

Gauge Field Theories

Paul H. Frampton
Benjamin–Cummings, Menlo Park, Calif. (dist. Addison–Wesley, Redwood City, Calif.), 1987. 584 pp. $44.25 hc
ISBN 0-8053-2584-0

The subject of gauge field theories grew in the last 50 years out of efforts by particle physicists to understand the workings of the world at short distances. It blossomed in the late 1960s and early 1970s into what is now called the "standard model" of particle physics, based on an $SU(3)\times SU(2)\times U(1)$ gauge field theory. These two books are attempts to collect and organize the rich harvest of knowledge from the field into texts for advanced graduate students. Both are impressive and useful pieces of scholarship, but neither is an ideal textbook for the subject.

Stefan Pokorski's book is by far the more expensive of the two; its price tag will put it beyond the reach of most graduate students. But the reason for the high price is obvious: The book is a striking, beautiful piece of typesetting; it is a pleasure to leaf through the pages. Despite a high density of information, the equations and diagrams are clearly and accurately presented. Unfortunately, there is not enough text to go with them.

Pokorski has not fallen into the trap, all too common, alas, in texts of this kind, of simply parroting derivations from the literature. It is obvious, if you know the subject, that he has made a real effort to organize the literature in his own way. In particular, the beginning of each chapter contains a useful introduction to the material, and the first, introductory chapter of the book provides a nice overview. Once the derivations start, however, he does not put in enough connective tissue. It is easy to follow the material locally, from one step to the next. But there is little attempt to explain its global significance. I think that this will make it difficult to use the book as a primary text for students who have not already seen the material. They may end up knowing the complicated derivations without understanding the simple facts, the body of lore that makes the subject intelligible. Still, the book's technical completeness and clarity will make it a valuable reference on library shelves. Physicists who know the subject will find it a useful place to check a sign (Pokorski, bless his heart, uses $g^{00} = +1$) or a coefficient in a difficult equation.

Paul H. Frampton's book, while having the same title, is completely different. Though it is not cheap, it is half as expensive as Pokorski's—and looks it. Typed rather than typeset, in the usual style of the Frontiers in Physics series, it has more pages and fewer lines. It won't win any prizes as modern art—but it will be far more useful for students than the Cambridge University Press item, both because students can afford it and because they are more likely to be able to extract the right kind of information from it.

Pokorski treats gauge field theory as a collection of mathematical tools. He is not interested in presenting the mathematics of the subject rigorously, but he does present it divorced from its historical roots in the description of particle interactions. He says explicitly in the preface that "no attempt has been made to review systematically the present status of the theory of fundamental interactions." It would have made the book far more useful had Pokorski at least done a more complete job of indicating how the mathematical tools were related to the particle physics from which they grew. The hard and interesting part of physics, after all, is not the mathematics for its own sake, but the connecting of nontrivial mathematics with apparently complicated phenomena. In the process, if all goes well, the phenomena become simpler and more understandable, and the mathematics begins to make much more intuitive sense in the explicit context of a model of the physical world.

For a real theoretical physicist, to study mathematics without phenomena is not unpleasant, but it is sterile, while to gather phenomena without mathematical description is unsatisfying stamp collecting. Frampton has tried to make the connection, although he does not always succeed. Like Pokorski, Frampton does not attempt a systematic review of the status of the standard model. But he does present gauge field theory as a series of vignettes, highlighting subjects that were important to the progress of the 1970s and early 1980s.

The beginning of the first chapter of Frampton's book is a discussion of symmetry in field theory without much inspiration or much connection to particle physics. I was put off in the first chapter by his inaccurate description of "accidental symmetry" and "pseudo-Goldstone" bosons. But once he gets to the Higgs mechanism and the standard electroweak model, the material is well presented in a chatty style that I find very readable. For the most part, the derivations are taken from the recent literature, with clear citations. But unlike Pokorski, Frampton supplies enough words to help the reader understand not only what is being done, but why. Often Frampton's discussion is clearer than that of the original paper, even though he seldom adds anything of substance. He simply explains things well.

Having organized his book around physics rather than mathematical tools, Frampton ventures further onto the speculative fringes of particle theory. Lattice gauge theories are briefly described. Eventually these ideas will be crucial to our understanding of strongly interacting gauge theories. Whether they will reach maturity in 10 years or 100 is a difficult question. The discussion of grand unification in the last chapter is sketchy, but Frampton does use it as an excuse to discuss the "effective gauge theory" picture. As I will explain below, I think that this treatment at the end of the book of the effective-field-theory idea is a case of too little, too late, but it is better than nothing. The connection between particle physics and cosmology is discussed in the same chapter. My personal view is that this is too much, too soon. Particle physicists tend to underestimate the width of the philosophical gap between their science