

ics. They support Niels Bohr's definition of an expert: a person who has made the largest number of mistakes in a given field.

The book is proof of the author's deep and wide understanding of our science. The examples are taken from almost every field of physics: atomic physics, statistical mechanics, the physics of transport processes, solid-state physics, nuclear physics and relativity. Moreover a large number of those insights come from his own work or from work his students performed under his guidance. Peierls is one of that decreasing group of physicists without prefixes such as "particle," "nuclear" or "condensed matter." There should be more of them. It is noteworthy that he left out particle physics—certainly not because of his lack of knowledge, but perhaps because he thought that in this field everything is a surprise.

There are a few items to criticize, however. Some of his examples are formal, mathematical ones; others—most of them, fortunately—deal with physical insight. Perhaps it would have helped if the reader were informed of this difference. Furthermore the book is limited by being a transcript of lectures; quite often the argument stops—probably because the hour was over—when it is about to become most fascinating. In many instances, one would have wished to get more of Peierls' wisdom. He certainly has more to say about some of his examples than we find in the book. A minor detail is the occasional presence of sloppy proofreading: The Euler equations were supposed to exemplify a nonlinear situation, but the omission of a velocity makes them appear linear; the Saha expression for the degree of ionization of a gas has two errors in it. All this is not very important. It is the style that counts. In this respect the book is a marvel. It shows us how to approach problems in physics and how to get at their depth in the most direct, elegant and penetrating way. It is not for beginners; this is a book for the connoisseur.

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Techniques and Applications of Path Integration

L. S. Schulman

359 pp., Wiley, New York, 1981. \$31.95

How far has path integral quantization developed since Richard Feynman invented it as a graduate student 40 years ago? The acceptance and the recognition of path integration as a major concept and technique for quantum

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physics is a fascinating chapter in the history of science. Since the time of Newton physicists have written most of physics in the language of differential calculus. When path integration entered the scene it was largely ignored, misunderstood or underestimated—even by Feynman himself, who in his Nobel Prize acceptance speech suggested that path integration was no longer as exciting a theory as its progeny, the diagrams. In 1973, Freeman J. Dyson spoke of path integration as a “missed opportunity.” In 1979 Barry Simon called it a “secret weapon.” By 1981 three books—by Simon (*Functional Integration and Quantum Physics*) by James Glimm and Arthur Jaffe (*Quantum Physics: A Functional Integral Point of View*) and the present book, by Lawrence Schulman—as well as conference proceedings, a monograph by Sergio Albeyero and Raphael J. Hoegh-Krohn (*Mathematical Theory of Feynman Path Integrals*) and several important papers are showing that the situation is changing.

Although in some respects these books are too diverse to be reviewed together, their appearance within a short period signals an event more important than their individual publications: that physicists are beginning to use stochastic analysis as well as the time-honored differential calculus in the formulation and solution of the great challenges of modern physics. Indeed path integration hinges on both stochastic and differential analysis; without one or the other it flies at best on only one wing.

Schulman's book belongs on the same shelf as the book by Feynman and Albert Hibbs. It discusses many problems not found in Feynman and Hibbs, such as caustics, multiply connected configuration spaces, systems with random impurities, particle production by black holes, and renormalization and scaling for critical phenomena. But it presents them in the same spirit that Feynman and Hibbs did and often asks the reader to rely on intuition rather than definitions.

It is a pleasure to watch Schulman's “balancing act” (his own words, page 63), and one can discover the deep truths behind what he does if one tries to make mathematical sense of his phenomenological approach, in, for example, the whole subject of stochastic analysis behind the balancing act of setting $(\Delta \text{ distance})^2 / \Delta \text{ time}$. His quick heuristic proofs are usually illuminating and there is also good physics to be learned if one tries to work out the undetermined factors or to make sense of the undefined factors, for example, the undetermined factors in the caustic problem or the undefined factor in the scattering amplitude (page 160, $\partial^2 F / \partial p' \partial p''$ is undefined because F is

not a function of all the components of p' and p''). The book is a good source of problems for graduate students looking for PhD dissertations in this area. The bibliography and notes at the end of each chapter are very helpful. There are, of course, omissions and erroneous comments, which can be corrected by looking up the quoted references and references therein.

Schulman admits to not dotting all mathematical i 's. However, even in an intuitive presentation the notation should distinguish between a path x and its value $x(t)$, particularly since the path x is the variable of integration. There are other misleading parts of the presentation (for instance, on page 86 the picture and caption of a focal point is given as the intersection of two classical paths) but they can be forgiven in view of the rich variety of applications presented by the author. Because applications presuppose specialized knowledge, a wide grasp of physics is necessary to write a book on applications of path integration. Schulman has given us such a book and has written it in a style that makes it lively reading.

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Thermoluminescence Techniques in Archeology

S. Fleming

241 pp. Oxford, New York, 1980. \$39.50

The thermoluminescence dating method is a relatively recent addition to the field that has become known as “archeometry,” the application of physical science techniques to problems in archeology and art history. Since its conception in the early 1960s, thermoluminescence as a method of dating archeological materials has held great promise of providing chronological information complementary to radiocarbon dating because it can be applied to heated, inorganic artifacts (such as pottery sherds) while radiocarbon dating is used on organic materials (such as charcoal). Only in the last several years have the major complications in thermoluminescence dating been overcome to open the way for attempts at routine analysis. An excellent general review of TL dating was given by Martin Aitken in *Physics and Archaeology* (Clarendon Press, 1974). The publication of a detailed description of TL dating techniques now seems appropriate.

Such a publication is offered by Stuart Fleming. Currently scientific director for the Museum Applied Science Center for Archeology of the University of Pennsylvania Museum, he is cer-

tainly well qualified to write a book of this nature. While at Oxford University, he performed some of the basic research leading to the refinement of TL dating and has published scientific articles on TL methods that have become standard reference material for those in the field.

Fleming first presents the basic principles of the method and the methodological details of the dating techniques, then discusses several of the more important archeological problems to which thermoluminescence dating has been applied. The chapters on methodology are concerned primarily with the three most widely applied TL dating techniques—inclusion, fine-grain and pre-dose techniques. For each of these, Fleming describes sample preparation, measurement procedures, data analysis, age calculation and sources of error. While he has attempted to avoid the more rigorous mathematical concepts, the mathematics is still rather complex. The excellent figures and tables are a definite asset of this section. Brief mention is also made of two other TL dating methods, the subtraction and zircon techniques, which are valuable in special situations and are less commonly applied. Thermoluminescence measurements on nonceramic materials, such as heated flint and stone, are not discussed.

The section on TL applications is perhaps the most significant contribution of the book, for, as the author states in his preface, “almost as swiftly as the finishing touches have been put to the technical elements of the TL method over the past three years, the archeological community has become disillusioned about its practical progress, i.e., its ability to produce dates.” To dispel this opinion, Fleming offers accounts of TL dating results for several important archeological problems. Among these are the *Bandkeramik* pottery ware of Central Europe and the Nok culture terracotta sculptures of Nigeria. Also discussed are applications in the authentication of Renaissance terracottas and ancient bronzes. In addition, a comprehensive listing of TL dating results is offered as an appendix.

One disappointment is to find the references listed in the order in which they appear in the text. Listings of this kind are awkward when one is searching for articles by a particular author. An alphabetical listing would have been preferred.

This book will be of value primarily to active researchers using thermoluminescence dating, although it is also recommended for readers with a general interest in archeological dating. An understanding of basic concepts in physics and mathematics is desirable.