ly imaginary time, the Feynman path integral becomes a Wiener integral; the Schrödinger equation (with its imaginary time-derivative) turns into the parabolic diffusion or heat equation, for which the Wiener integral provides a solution. This solution for the Schrödinger equation has become known as the Feynman–Kac formula. It has played a fundamental role in Euclidean constructive field theory and in statistical mechanics.

The book by Johnson and Lapidus deals with various approaches to making the Feynman path integral into a mathematically meaningful object. The first few chapters present a considerable amount of background material on measure theory, functional analysis, and the traditional formulation of quantum mechanics, as well as two chapters on Wiener measure and stochastic processes. This material can be particularly useful for a theoretical physicist whose mathematics may be a bit rusty.

Chapter 7 contains a detailed heuristic introduction to Feynman path integrals. It turns out that there are several independent approaches to a mathematically satisfactory definition: Edward Nelson's approach via the Lie–Trotter product formula, Kac's original analytic-continuation-in-time approach, as well as those developed by the authors, based on analytic continuation in mass and imaginary resolvents (which form the subject of later chapters). The detailed mathematical treatment is often interspersed with interesting remarks and heuristic material that eases the flow. Throughout the book one finds examples of application to problems in nonrelativistic quantum mechanics.

The second topic of this book is the Feynman operational calculus. It was invented by Feynman in 1951 in an attempt to "disentangle" exponentials of noncommuting operators such as often occur in time-ordered perturbation theory (commonly known as the Dyson time-ordered exponential). Feynman realized that his highly heuristic approach poses serious mathematical problems, and this book appears to be a first systematic, mathematically rigorous study of this subject.

The authors discuss several methods of making sense of the Feynman heuristics: via the path integral, via a "generalized Dyson series," and via a more general noncommutative calculus. These chapters may well be of interest to physicists involved in "noncommutative geometry."

The last chapter deals with other work related to the book's topics, ranging from alternative approaches to the path integral (so-called Fresnel integrals) to a very readable survey of the influence of Feynman integrals on contemporary mathematics and physics. In particular, the authors discuss low-dimensional topology and Edward Witten's approach to knot invariants, and they end with a discussion of Maxim Kontsevich's work on deformation quantization.

The list of references is quite extensive (though the acronyms, such as "GelKLLRT" are sometimes distracting, forcing the curious reader to flip back to the bibliography to find out to whom the authors refer).

I would recommend this book to serious students of the subject, if it were not for the prohibitive price; let's hope that the publishers will release a more reasonably priced paperback, accessible to graduate students and emerit(ae)i.

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The Charm of Strange Quarks: Mysteries and Revolutions of Particle Physics

R. Michael Barnett, Henry Mühry, and Helen R. Quinn
Springer-Verlag, New York, 2000. $39.95 (302 pp.). ISBN 0-387-98897-1

Despite the intense research that has been done in particle physics, the public remains mostly mystified by the subject. The field's conceptual and mathematical complexity is a barrier even to individuals who are interested in particle physics but lack the skills necessary to unravel its mysteries.

We rely on K–12 education to provide citizens with the foundations of science that will enable them to understand new scientific developments. Yet physics courses at the high-school and even introductory-college levels are preoccupied with classical physics; little time is left for 20th-century physics. Most high-school physics curricula, even the *National Science Education Standards* (National Academy Press, 1996), do not move past atomic structure and radioactive decay, the physics of the 1930s. Until recently, textbooks included little, if any, discussion of elementary particles.

The preface to *The Charm of Strange Quarks* contains a clear statement of intent "to bring the excitement and a basic understanding of this fundamental topic to the public and especially to students." In the first two-thirds of the book, the authors present the Standard Model of particle physics and related elements of cosmology. Concepts and discoveries, starting with the structure of the atom, are emphasized. Although it feels like a traditional text, this book has no questions or problem sets at the end of the chapters. Using few equations, the authors augment the main text with drawings, photographs, and boxed inserts, providing concise physics explanations or recognition of the contributors to this work. The emphasis on the work of scientists is an important feature, with the first chapter dedicated to the story of the independent discoveries of the J/ψ particle by physicists working at SLAC and at Brookhaven National Laboratory.

While the mathematical complexity is absent, the book is not "light" reading. The language is sufficiently technical that a solid understanding of basic physics is essential. The history of the discoveries is presented in a coherent fashion, with clear and thorough explanations of the significance or surprise that each contributed. The interdependence of experimental and theoretical physics is accurately portrayed, with examples where each breaks new ground. The reader will be convinced that the Standard Model is not a far-fetched theory but an established framework grounded in both mathematical reasoning and experimental verification. Not only is the Standard Model well explained, but its limitations, such as its inability to predict quark masses or to unify strong and electroweak forces, are clearly stated. The relevance of particle physics to cosmological issues, and new theories addressing unresolved questions, are explored (in chapters 8 and 9) in fascinating yet readily comprehensible terms.

Although it is a thorough presentation, *The Charm of Strange Quarks* appears disjointed in some places, especially in chapter 3 in which flavors of quarks, discussed on page 52, are reintroduced on page 62 as if they had not been discussed previously. At times, the explanations are too short and would benefit from additional elaboration, as in the case of the explanation of quark masses on page 68. The book includes a few real-world analogies to help visualize difficult concepts, such as exchange of virtual particles during an interaction. Additional analogies would be useful.

The last third of this book is devoted to some conventional appendices, plus appendix D, an introduction to basic physics concepts as applied to particle physics. This section is less inhibited in its use of equations and quantitative concepts. It contains exercises for the reader and is clearly intended as a supplement to an introductory physics course.

The book is recommended as a supplementary text for introductory college courses or for advanced high-school courses; science teachers will find it useful for updating their knowledge in an ever-expanding field of physics research.

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Waves in Dusty Space Plasmas

Frank Verheest
Kluwer Academic, Norwell, Mass., 2000 $115.00 (264 pp.). ISBN 0-7923-6232-2

Particulate matter in the universe exists in sizes ranging from macromolecules to micron-sized grains to even larger pebbles and boulders. When such particles are present in a plasma, they become charged (usually negatively because of the greater mobility of electrons) and thus contribute to the plasma dynamics as a separate "species." These particles have much larger masses and usually larger charges than those of the plasma ions, but much smaller charge-to-mass ratios. This so-called dusty plasma contains a highly diverse range of collective modes of oscillation, unstable behavior, and linear and nonlinear waves.

The grains of a dusty plasma also have a range of sizes and shapes, and the charge can fluctuate in time, leading to highly complex behavior. Over the years, dusty plasmas have been studied mostly as a theoretical construct, due to a lack of direct observations of dust in space. In the past two decades, however, the situation has changed dramatically: First Voyager mission's observations revealed new planetary rings and intricate structure ("spokes") in the rings themselves; more recently, the Galileo and Ulysses missions made measurements of dust streams from Jupiter, and rocket flights collected data through noctilucent clouds high in Earth's atmosphere.

Dusty plasmas are also now easily made in the laboratory, will be subjects of some experiments on the International Space Station, and, because of self-grown contaminants, occur in plasma-processing devices. Theory and simulations have managed to keep up with this explosion of data, leading to a new and exciting subfield of plasma physics.

In *Waves in Dusty Space Plasmas*, Frank Verheest has captured the diversity of phenomena, the excitement, and the challenges of studying waves in dusty plasmas in space. Verheest has contributed in many significant ways to the understanding of these plasmas over the years and has written an oft-cited review of waves (*Space Science Reviews*, volume 77, page 267, 1996). This book is no rewrite of the review article, but a new, major compilation and summation of this rapidly evolving subject, with its own wide range of topics.

The book naturally divides into three parts. The first part introduces basic concepts, such as charging of dust grains, and provides the observational evidence in space for dusty plasmas. The second part develops the formalism for treating dust as a separate plasma species and describes the basic electrostatic and electromagnetic wave modes in a dusty plasma; unlike many plasma textbooks, the emphasis here is on nonlinear waves as much as linear modes. The final third of the book discusses more complex processes, such as dust grains with fluctuating charges or a distribution of sizes, as well as the astrophysically important issue of dust in self-gravitating systems.

Verheest has written a book that is both highly informative and engagingly readable. His use of the first person throughout the text and his honest discussion of controversial points contribute to the personal style of this book. He assumes the reader has basic background in plasma physics but is not an expert in dusty plasmas or space plasmas. He is quick to point out that, in this still emerging field, a proper mechanism to introduce dust into the plasma equations in a mathematically rigorous manner does not yet exist; instead he extends the standard formalism in a natural way.

His approach is based on a fluid treatment of the plasma, which is almost always valid here, given the mass of grains relative to those of the usual plasma components and resulting behavior at frequencies much lower than those typically found in plasmas. He gives an excellent description of the basic physics, and the reference list he includes is complete and by itself well worth the price of the book.

Most of the treatment of waves (linear and nonlinear) is analytical. Personally, I think some numerical solutions of these complex plasma equations displayed graphically, such as are found in S. Peter Gary's noteworthy monograph on plasmas without dust (*Theory of Space Plasma Microinstabilities*, Cambridge U. Press, 1993) would add further insight. Overall, Verheest's treatment is excellent and is highly recommended, both for those who are just starting out in the field and for more established researchers.

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Chernobyl Record: The Definitive History of the Chernobyl Catastrophe

Richard F. Mould
IOP, Philadelphia, 2000. $57.00 (402 pp.). ISBN 0-7503-0670-X

My problems with Richard F. Mould's *Chernobyl Record* start with the words "definitive history" in the title. The book is decidedly not a history of events that resulted in the catastrophe. It is rather a mixture of chronicle, traveler's journal, summaries of some aspects of nuclear civilization, and a great deal of statistics. The tone of the narrative varies from emotional eyewitness account to overly dry technical description. Along with authoritative, official information, there are bits with less-than-evident significance, such as pictures of the author's Soviet visa or a camel in the Kazakh steppe. While the comparison of the Chernobyl explosion to the nuclear accidents at Three Mile Island and Tokaimura seems to be too laconic, the comparisons to the Hiroshima and Nagasaki atomic explosions and to nuclear weapons test sites seems out of place.

The 1986 Chernobyl catastrophe was indeed a multidimensional phenomenon, and it may still be too soon to attempt a "definitive" history. But what is striking is that Mould has not even tried to address the very basic historical question: whether Chernobyl was just one of quite a few (even though the worst) accidents of the nuclear era, or whether the Soviet regime was mainly responsible for this misfortune. The question is much