

lasted until Pauli's death in 1958. *Atom and Archetype*, the collection of letters, is a careful translation by David Roscoe of a German edition published in 1992 with the assistance of the physicists Markus Fierz and Charles Enz, leading Pauli experts. Jungian analyst Beverley Zabriskie contributed the introductory essay, "Jung and Pauli, A Meeting of Rare Minds," to the English-language edition.

Among the 80 letters in *Atom and Archetype* are 39 by Pauli, and appendices containing several lectures by him—and an unpublished essay "Modern Examples of Background Physics" ("Hintergrundphysik").

This essay was found with the correspondence between Pauli and Jung and addresses itself to the principal theme of their exchanges. What Pauli had in mind was a description of nature integrating both physics and psyche. He wrote in the introduction: "In order to achieve this integrated description of nature, it seems to be necessary to have recourse to the archaic background of the scientific concepts. In the following brief commentary, I shall attempt to outline and explain, how the physicist, in having recourse to these facts, is of necessity bound to move from this background and end up in the world of psychology."

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Spin in Particle Physics

▶ Elliot Leader
Cambridge U. Press, New York,
2001. \$130.00 (500 pp.).
ISBN 0-521-35281-9

Elliot Leader is a particle theorist who has made significant contributions to what we now call the standard model of elementary particle physics. He is the author, with Enrico Predazzi, of a two-volume book on gauge theory and the standard model (*Introduction to Gauge Theory and Modern Particle Physics*, Cambridge U. Press, 1996). In *Spin in Particle Physics*, Leader applies his extensive knowledge and broad judgment to this subject as well. At a time when much of the effort in particle physics goes to issues beyond the standard model—and even to trans-Planckian physics, with an attendant degree of speculation—Leader's book offers a fine discussion of the concrete topic of spin.

The book's preface establishes the case that spin is an essential complica-

tion in the physics of elementary particles—as a counter to the oft-stated dismissal of spin as "an inessential complication." As Leader states, he has three aims in the book, to give a simple pedagogical exposition of spin in relativistic physics, to describe the experimental side of spin physics, and to show the relevance of spin-dependence both in testing quantum chromodynamics (QCD) and in elucidating the structure of the electroweak interactions.

For this review I divide the chapters of the book into three groups corresponding to the three aims. Leader spends the first group (five chapters) discussing the theoretical basis of spin in quantum theory. Those chapters include discussions of spin in both nonrelativistic and relativistic quantum theory and in the relativistic case for both massive and massless particles. The book's preface defines the notation clearly. Leader uses the Bjorken-Drell gamma matrices, introducing the Weyl representation in only one of twelve appendices that provide definitions and examples for some of the topics discussed in the text. He derives the action of the Lorentz group on both massive and massless particles (using both Wick and Wigner rotations) and the action of the discrete symmetries—parity, time reversal, and charge conjugation. He explains the Thomas precession in two different ways, first using a simplified argument and later deriving it as a case of the general Bargmann-Michel-Telegdi equation. He also discusses the spin density matrix, transition amplitudes, and observables of reactions, giving specific examples for the various cases involving particles of spin 0 and 1/2. The five chapters serve as a fine reference for the quantum theory of spin.

Leader devotes the second group (three chapters) to experimental issues in the production of polarized hadrons, electrons, and positrons and to the analysis of polarized states. He surveys various types of polarized sources and targets, including the "Siberian snake" method of avoiding depolarization of beams by resonances during the acceleration process. He discusses the conditions under which the Sokolov-Ternov effect leads to a large "natural" polarization of electrons in a perfect storage ring. These chapters provide much more detail than one would expect in a book on spin and will be useful as a starting point for physicists entering the field.

The final group (six chapters) starts with a succinct introduction to QCD and the electroweak interactions. Next Leader describes what has

been learned, what can still be learned, and what topics are still completely mysterious in particle physics within the standard model. After a review of deep inelastic lepton-hadron scattering, he emphasizes issues related to the spin-dependent scaling functions—from the standpoint of the parton model and its field theory justification [using the Feynman diagram approach]. He discusses the “spin crisis” in the context of attempts to use data to find the carriers of spin in the nucleon, QCD corrections, inclusive and semi-inclusive reactions, and elastic scattering, among other topics, always emphasizing issues connected to spin dependence. The production of polarized hyperons and antihyperons is one such issue still shrouded in mystery.

I am enthusiastic about this book. It is carefully and clearly written. Each of the three sections will be useful to a specific audience. The book as a whole should be in every university and research institution library; however, it is not suitable as a text for a graduate course in particle physics, nor will many individuals find it a necessary part of their personal libraries.

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Fundamentals of Cosmology

James Rich
Springer-Verlag, New York, 2001.
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ISBN 3-540-41350-2

James Rich's *Fundamentals of Cosmology* was a pleasure and distraction to review. The book provides a comprehensive and thorough explication of current cosmology at a level appropriate for a beginning physics graduate student or an advanced and motivated undergraduate. It covers all the relevant concepts of cosmology and pertinent general relativity and contains a significant number of exercises, with solutions to a sample set. This book clearly is a result of the refining of notes from a course on cosmology. (Rich regularly teaches a cosmology course at the University of Paris and l'Ecole Polytechnique in Paris.)

While in principle it would be possible to learn modern cosmology from *Fundamentals of Cosmology* from scratch, most readers would find it helpful to have been exposed first to a slightly more introductory text, such as *First Principles of Cosmology* by Eric V. Linder (Addison-Wesley, 1997).

Linder is appropriate to upper-level undergraduate physics majors and provides clear, logical explanations of the fundamental principles. There are other, more introductory books, such as *Introduction to Cosmology* by Matts Roos (Wiley, 1994 and 1997), and popular books that introduce the reader to the basic concepts. Rich's approach is both mathematically and conceptually advanced and is set to develop the reader's understanding of cosmology to a deeper level than a first introduction.

Fundamentals of Cosmology does present a clear, accurate, and complete description of current cosmology. The book does not retrace the history of cosmology but goes directly to the current observational status and gives a direct approach to modern cosmology. It provides a summary of current observations and mathematical underpinnings of the physical principles. This is an extremely valuable contribution in the field, which has been changing rapidly as a result of new technology and new theoretical motivations from the related field of high-energy physics. Concepts, such as the current acceleration of the universal expansion as a result of a mysterious “dark energy,” exotic dark matter, and scalar fields, are placed in the context of our current standard model of cosmology.

A shortcoming of the book—one that renders it conservative—is that string/M theory and the possibility of extra dimensions are not discussed even briefly. These topical and speculative areas may turn out to be relevant or generate new concepts that become features of cosmology. The book is, however, modern and up to date in areas that were considered rank speculation a few years ago.

These are exciting times for cosmologists. New telescopes, space missions, and instruments are generating data at an impressive rate, and new experiments are going online almost daily. We can anticipate answers and insights to some of the big, long-asked questions. This book provides a good look at the intellectual effort and a solid foundation for the new discoveries soon to come.

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NEW BOOKS

Energy and Environment

Encyclopedia of Global Environmental Change, Vols. 1–5. Vol. 1: The Earth System: Physical and Chemical Di-