The Early Universe: Facts and Fiction. G. Boerner. 439 pp. Springer-Verlag, New York, 1988. Price: $69.00 ISBN 0-387-16187-2. (Reviewed by L. Perivolaropoulos and R. Brandenberger.)

Cosmology is an exciting and rapidly developing field. However, until recently, there has been no textbook that covers the recent developments. *The Early Universe: Facts and Fiction* by Boerner attempts to fill this gap in the literature.

The author has written a book that presents the foundations of general relativity and particle physics that are required in order to fully understand the recent developments in cosmology. He discusses in detail the observational basis of modern cosmology and surveys most of the relevant recent theoretical and observational developments.

The author intends the book to be used by particle physicists interested in learning about cosmology and by astronomers who want to study the theoretical foundations of modern theories. The book requires good background knowledge of general relativity and some basic knowledge of quantum field theory and group theory. Thus it will not be useful as a textbook at the undergraduate level. However, it could well serve as a textbook for a graduate level cosmology class.

The book is divided into three parts. In the first, an introduction to the standard Big Bang model is given. In the first chapter, Boerner derives the cosmological solutions of Einstein's equations. He then discusses the status of the crucial observations of cosmological significance and the thermal history of the early Universe. The second part of the book is devoted to particle physics and its relevance to cosmology. Boerner presents a nice discussion of gauge theories and the Standard Model of particle physics (not to be confused with the standard Big Bang cosmological model) and then introduces the reader to grand unified theories and their many implications for cosmology. Separate chapters are devoted to relic particles from the early universe, baryogenesis, and the inflationary universe. The third part of the book deals with dark matter and galaxy formation. Following an introductory chapter summarizing the basic physical principles that are involved in determining how matter clusters, Boerner discusses the growth of linear density perturbations and the influence of the various types of dark matter. The final chapter is devoted to computer simulations of large-scale structure.

The selection of topics is superb. The book gives a well-rounded survey of modern cosmology and covers most issues of relevance to current research. The book goes much further than Weinberg's excellent book, *Gravitation and Cosmology*. For the first time, a graduate student can learn about current topics like the inflationary universe, cosmic strings, dark matter candidates, the solar neutrino problem, axions and their role in cosmology, galaxy formation, and N-body simulations of large-scale structure in one book. The book is nicely illustrated (including an interesting selection of plates), and the many tables and graphs contain a wealth of information. This will render it useful to a broad range of the physics community, in particular to working cosmologists. The book contains a nice balance of theoretical concepts and observational facts.

Most of the chapters are well written. In our opinion, the observational results are very well presented and should be accessible to most physicists. Similarly, the chapters on gauge theories and grand unified theories present a good summary of a huge field. However, the same is not true of some of the other sections. The first chapter on cosmological models requires too much background knowledge of general relativity, especially because most of the results are not used in the remainder of the book. Similarly, Boerner chose to discuss linear gravitational perturbation theory using a formalism that is more difficult than others and not widely used. The discussion of inflationary universe models is somewhat outdated and focuses too much on New Inflation, a model that does not work, and not enough on Chaotic Inflation, a model that has a chance of working.

In summary, Boerner's book, *The Early Universe: Facts and Fiction* is an excellent introduction to and review of modern cosmology. It is, however, also a book that is not self-contained and in certain sections not sufficiently pedagogically written. Despite the few drawbacks, we highly recommend the book to graduate students who want to enter this exciting field, to teachers who are looking for a textbook for a graduate level class in cosmology, and to any particle physicist and astronomer who would like to learn about the recent developments in cosmology.

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Beyond the Atom: The Philosophical Thought of Wolfgang Pauli. K. V. Laurikainen. 234 pp. Springer-Verlag, New York, 1988. Price: $29.00 (paper) ISBN 0-387-19456-8. (Reviewed by James L. Park.)

In the latter half of the 20th century, teachers of quantum theory have routinely paid lip service to the so-called Copenhagen interpretation, a doctrine generally understood to include at least (a) the standard rules for calculating measurement statistics from wavefunctions, and (b) a new philosophy, rather ill-defined but characterized by such terms as complementarity and indeterminacy. Followers of such practical physicists as Dirac and Feynman have generally elected to use (a) and just ignore (b). By contrast, more philosophical physicists, for whom successful empirical predictions alone provide inadequate fulfillment of intellectual yearnings, are drawn inevitably to explore the mysteries and implications of (b). The latter group, whose special heroes might be Bohr, Einstein, Schrödinger, Heisenberg, or Pauli, will find Laurikainen's book quite stimulating.

Studies of (b) have always been both fascinating and perplexing. The writings of Bohr on the Copenhagen inter-

pretation, though extensive, are notoriously obscure. Einstein and Schrödinger made their positions clearer; but, as opponents of Copenhagenism, neither one wrote any apologetics in its behalf. The philosophical works of Heisenberg describe a "Copenhagen interpretation" that is sometimes contradictory to Bohr's. Besides Bohr and Heisenberg, there was a third great developer of Copenhagenism—Wolfgang Pauli, but he died prematurely, having published only fragments of his evolving quantum philosophical thought.

More than a decade ago, Laurikainen undertook a major investigation of Pauli's philosophy by probing the Pauli Letter Collection at CERN. There he discovered a remarkable trove of correspondence between Pauli and Markus Fierz, a friend and fellow theoretical physicist. These informal letters touch upon many subjects, including physics, psychology, theology, ontology, and epistemology; and they suggest that, had Pauli lived a bit longer, he might well have produced the definitive "Copenhagen interpretation," characterized by greater philosophical depth and breadth than the efforts of either Bohr or Heisenberg.

The Pauli–Fierz correspondence was in German, and Laurikainen's book was originally published in Finnish in 1985; the 1988 edition is a complete translation into English. The main body of the work consists of ten chapters, each an essay that attempts to reconstruct some facet of Pauli's thought from clues provided in the correspondence. Selections from the letters are quoted at length, so there is no suspicion on the part of the reader that Pauli is being manipulated out of context; in this way the author makes all the more persuasive his conjectures as to what Pauli might have said in formal papers had he lived to write them. The quotations are always provided in the original German, with English translation available in an appendix. Three additional appendices contain reprints of papers by Laurikainen that summarize Pauli's philosophical thought.

Although much of his inspiration seems clearly rooted in quantum mechanics, Pauli's philosophical speculations far transcend the strict domain of physics. There is here a haunting parallel to the more familiar case of Newton, whose quest for truth embraced not only his celebrated mechanical and optical studies but theological and even alchemical investigations as well. Similarly, Pauli sought to understand a reality composed not merely of matter but also of psyche; indeed, he regarded the fashionable rationalistic and materialistic reductionism that has enveloped science since the 17th century as a dangerous intellectual mistake.

With greater conviction than Bohr or even Heisenberg, Pauli stressed that the conscious observer is not a detached spectator but rather a participating actor in the drama of quantum phenomena; complementarity is more a relation between matter and spirit than between alternate experimental arrangements. For Pauli, the most significant lesson of quantum mechanics appears to have been that the locus of causality resides at the statistical level rather than that of individual events. From this failure of classical causality he extracted the seminal conclusion that reality includes an essential element of irrationality quite alien to the Cartesian faith of most scientists of the past three centuries.

In this fundamental irrationality, Pauli saw connections between quantum physics and great metaphysical ideas of the past that in his view ought not to have been discarded from natural philosophy. There was room in his universe for something like the anima mundi, the world soul of the Middle Ages. From the disparate worlds of quantum physics and Jungian psychology he labored to construct a unified psychophysical reality. And he even attempted to extract from the irrationality revealed by quantum mechanics a new perspective on the ancient problem of evil, a "quaternarian" as opposed to "trinitarian" theology in which God has four parts, of which one is destructive.

Contemporary physicists whose philosophical interests are narrowly prescribed by commitments of faith in materialism or instrumentalism will obviously regard such philosophical speculations as baffling or meaningless. Those, however, who share with Pauli a passion to comprehend a larger reality—physical and psychical, rational and irrational—will find Laurikainen an excellent guide through the provocative musings of a great 20th-century scientist.

James L. Park, a Professor of physics at Washington State University, studies mathematical and philosophical foundations of quantum mechanics and thermodynamics.

BOOKS RECEIVED

The Atomic Scientists: A Biographical History. Henry A. Boorse, Lloyd Motz, and Jefferson Hane Weaver. 472 pp. Wiley, New York, 1989. Price: $27.95 ISBN 0-471-50455-6.

Band Structure Engineering in Semiconductor Microstructures. Edited by R. A. Abram and M. Jaros. 388 pp. Plenum, New York, 1989. Price: $85.00 ISBN 0-306-43080-0.

The Compact Disc: A Handbook of Theory and Use. Ken C. Pohlmann. 288 pp. A–R Editions, Madison, WI, 1989. Price: $29.95 (paper) ISBN 0-89579-228-1.

Ionizing Radiation Effects in MOS Devices and Circuits. Edited by T. P. Ma and Paul V. Dressendorfer. 587 pp. Wiley, New York, 1989. Price: $69.95 ISBN 0-471-84893-X.

Klaus Fuchs, Atom Spy. Robert Chadwell Williams. 267 pp. Harvard U.P., Cambridge, 1987. Price: $25.00 (cloth) ISBN 0-674-50507-7; $12.95 (paper).

Laser Holography in Geophysics. Edited by Shuzo Takemoto. 229 pp. Halsted (Wiley), New York, 1989. Price: $49.95 ISBN 0-470-21265-9.

Laser Microanalysis. Lieselotte Moenke-Blankenburg. 288 pp. Wiley, New York, 1989. Price: $69.95 ISBN 0-471-63707-6.

Laser Microfabrication: Thin Film Processes and Lithography. Edited by Daniel J. Ehrlich and Jeffrey Y. Tsao. 587 pp. Academic, New York, 1989. Price: $89.50 ISBN 0-12-233430-2.

Lectures on Fourier Series. I. Solymar. 120 pp. Oxford U.P., New York, 1988. Price: $45.00 (cloth) ISBN 0-19-856198-9; $19.95 (paper) ISBN 0-19-856199-7.