the techniques themselves; thus Auger electron spectroscopy is covered in a page and a half—just enough to remind the reader of the principles involved. As another example, in the chapter on heterogeneous catalysis, Morrison uses a summary of the oxidation of olefins on molybdena catalysts as a major illustration, but anyone interested in how the experiments were done and how the various conclusions were reached must go to the original sources. For this reason the author provides an unusually extensive bibliography; the book lists more than a thousand references, covering the literature through 1975. Incidentally, this bibliography would have been even more useful if the titles of the articles had been included.

Judging from a few spot checks the format can be very effective. For instance, I had occasion to look up the photolysis of water on a $TiO_2$ surface and quickly found an outline of the currently accepted mechanism and a couple of key references. Inevitably, however, there are omissions. In another check, involving the subject of surface-free energy and surface segregation, I found nothing at all.

Morrison's book is not easily categorized. It does not develop the material as methodically as one would want in a textbook; it is too selective to be a research review, and it contains too few "facts" to serve as a handbook. However, better than any other book I know of, it catalogs the ideas and concepts that occupy surface scientists at this time.

PEDER J. ESTRUP
*Department of Physics*
*Brown University*
*Providence, R.I.*

## The First Three Minutes: A Modern View of the Origin of the Universe

**S. Weinberg**
188 pp. Basic Books, New York, 1977. $8.95

Cosmology, in the words of Steven Weinberg, is a subject that has always been surrounded by "an aura of the disreputable." It is a daring leap into the unknown, a high-wire walk on a slender empirical thread. Yet it never fails to attract some of the finest minds of our profession.

The justification for this descent from normal standards of scientific prudence is obvious enough. The quest for the origin of the universe is fascinating enough to generate an irresistible temptation to give it a try, using the best available theoretical concepts, despite the risks. And in a civilization that asks its people to look to science, rather than mythology, for the key to this eternal riddle, scientists would abdicate a significant part of their social role if they refused entirely to speculate about such matters. For this reason cosmology, more than any other area of science, is a field in which the scientist's duty has not been fully discharged until the work has been popularized.

That this task should fall to a physicist celebrated for his fundamental contributions to elementary-particle theory is neither surprising nor unprecedented. Every gain in our understanding of subatomic matter and field theory makes the extrapolation to early times that much more plausible. Thus a generation ago the nuclear theorist George Gamow became the co-founder, and also the leading popularizer, of the big-bang cosmology. Weinberg's choice of title represents his homage to this predecessor, for it celebrates the moment (about 220 seconds after $t = 0$) when the closure of the "deuterium bottleneck" permitted the start of nucleosynthesis. The primordial helium-to-hydrogen ratio fixed at the time represents our earliest experimental handle on the big bang.

As the late Ben Lee pointed out shortly before his untimely death last summer, a particle physicist has more to say about the first three *milliseconds*. But for the time being this earlier era, when all flavors of quarks and leptons existed in harmonious thermal equilibrium, remains beyond the reach of observation. Weinberg enters it in a chapter entitled "The First One-Hundredth Second," but only with the utmost caution. (Wild dreamers can look forward to an era of one grand unified field theory including quantum gravity and to a book entitled *The First Picosecond.*)

Weinberg also explores at some length the aftermath of the period in his title, the origin (at nearly one million years) of the cosmic microwave background. He relates in considerable detail the fascinating tale of how Arno Penzias and Robert W. Wilson accidentally confirmed this all-but-forgotten prediction of the big-bang pioneers, while investigating the noise background for the *Echo* communications satellite experiment. This was not the first time that practical-minded researchers who toil for "Ma" Bell have stumbled onto one of the keys to the universe, and shown the skill and nerve to follow the clues where they led; *ave*, Clinton Davisson and Lester Germer.

Weinberg's book is written with a lucidity and charm that rank him with the foremost of science popularizers. He guides the reader through some of the deepest concepts and arguments of modern science without resort to a single displayed equation. He does this with the aid of abundant simple graphs and charts. For the professional scientist or science student, there is a mathematical supplement at the end of the book, though most of us would find a more complete treatment, such as that in Dennis Sciama's *Modern Cosmology*, more nourishing fare.

Weinberg meets head-on the often-voiced fear that the presentation of speculative ideas will harm the image of science in the public vision. Such strictures apply *a fortiori* to cosmology, which has a capacity to evoke an emotionally violent response in some people. Every scientist who has spoken out on such matters is familiar with the avalanche of "crank" mail that is likely to ensue. Weinberg handles this problem with dexterity, neither overstating the case for the big-bang theory, nor crushing its beauty beneath an undue burden of qualifying adjectives. It is the best we have to offer, and a beautiful creation indeed, but we must remember that future generations may well find it naïve.

Perhaps the most important message a scientist can convey to a general audience is that in this imperfect world, perfect knowledge is not to be found. Everything we believe is tentative and subject to revision. In the end, scientists must appear before the public as implacable enemies of all dogmas, including their own. Weinberg performs this service admirably. It is rare indeed that one can say of a book that no one's library is truly complete without it.

ROBERT H. MARCH
*Department of Physics*
*University of Wisconsin*
*Madison*

## Scattering Theory in Quantum Mechanics: Physical Principles and Mathematical Methods

**W. O. Amrein, J. M. Jauch, K. B. Sinha**
691 pp. W. A. Benjamin (Addison-Wesley), Reading, Mass., 1977. $29.50 clothbound, $17.50 paperbound

The preface of this book notes in an understatement that "much of our knowledge about the physical world is derived from scattering experiments." The description of methods for the prediction of the results of such experiments forms a disproportionately small part of most books and courses on quantum mechanics. The attention lavished on discrete spectra in most such courses is justified only historically: they differ most qualitatively from classical theory. Indeed, for the first twenty years or so after its invention, the practitioners of quantum mechanics generally used the language and ideas of point eigenvalues even in scattering calculations, where they are inappropriate.

The situation has changed considerably during the last fifteen years. There are now at least eight books on quantum scattering theory in existence, and one may begin to question the need for more. The existing books, however, vary enormously in their range and focus of attention, particularly with respect to mathematical rigor. The present volume complements the others very well in this respect. Its focus is the mathematically rigorous formulation of quantum scattering theory in the language of functional analysis in Hilbert space, and its proofs should satisfy even mathematicians. Since exact proofs are space consuming, the inevitable price for such rigor is less breadth in the topics considered and in the physical discussion.

The authors are eminently qualified for their task. Joseph Jauch's attention turned more and more to mathematically rigorous formulations of quantum mechanics during the last years of his life and he made important contributions to scattering theory. Both Werner Amrein and Kalyan Sinha collaborated with Jauch at Geneva and have published significant papers of their own.

The book written by the three authors is well integrated in style of presentation and approach. About one third of it is devoted to the presentation of the mathematical background needed for a rigorous treatment of scattering theory. Whereas for most bound-state problems physicists can get away with ideas and intuition based on the geometry of finite-dimensional vector spaces and the spectra properties of matrices, particle scattering necessarily takes place in the continuous spectrum of the Hamiltonian and the full range of the theory of infinite-dimensional Hilbert space is needed. The authors start scattering theory from a time-dependent point of view, which is both mathematically and physically sound, and then extensively use the time-independent approach that eventually leads to the calculation of experimentally verifiable quantities.

The chapter that I found the most interesting is entitled "eigenfunction expansions." Here the authors make rigorous sense out of the non-normalizable eigenfunctions in the continuous spectrum, and they prove the completeness of the spectra of large classes of physically interesting Hamiltonians. They discuss the fact that the asymptotic behavior $r^{-3}$ of the potential is the dividing line where some of our intuitive ideas about scattering begin to break down, though not all of them already fail at this point. They prove for a large class of (non-central) potentials that the T-matrix is an $L^2$-kernel as a function of the angles, and continuous (in the $L^2$-norm) as a function of the energy. The reader should be warned, however, that the use of the superscripts + and − in this book is the opposite of what is customary. (This stems from the fact that when states and propagators are first introduced from a time-dependent point of view, then the cus-