most machine-gunned by a nervous guard at a Peruvian airbase as they prepared their radiometer for high-altitude flights on a U-2 spy plane. Their South American expedition was scientifically important as well: The fact that Smoot's group saw the telltale signal in the Southern as well as the Northern Hemispheres made their measurement of the CBR dipole anisotropy one of the first really convincing ones, because galactic contamination is so different in the North and the South.

It is hard to overstate the importance of the discovery of the CBR anisotropies. The rapid accumulation of data about the initial conditions since this discovery permits cosmologists at last to build theories on the solid ground of observation rather than on speculation. Smoot and Davidson start their book with a good popular introduction to the basics of modern cosmology and nicely intersperse background material as needed. Readers will also appreciate the summaries and transitional material at the ends of most chapters.

There is only one thing about the book that prevents me from giving it an unqualified recommendation. Smoot is the principal investigator for the DMR, and he surely deserves a good deal of credit for its success. However, his account of the history—in particular, his failure to give appropriate credit to several of his collaborators—has greatly disturbed other leading members of the COBE team. To cite just one example: Smoot claims that it was he who thought of removing the quadrupole anisotropy in analyzing the DMR data with his students in February 1992. In fact, a more junior COBE team member had suggested a no-quadrupole analysis months earlier, and it had been done and reported to the entire team in November 1991. Probably all scientists are tempted to exaggerate the importance of their own roles in discoveries in which they played a part. Smoot should perhaps have tried harder to resist this temptation.

In *Through a Universe Darkly*, Marcia Bartusiak, a well-known science writer, attempts something difficult. She tries to tell a story whose ending is not yet known: the saga of the quest to discover what sort of stuff the universe is made of. In the first half of her book, Bartusiak deftly sketches the contributions of the astronomers and physicists who played key roles in determining the ordinary-matter content of the universe, such as Edward Emerson Barnard (who gathered persuasive photographic evidence of interstellar dust clouds), Annie Jump Cannon (to whom we owe the standard OBAFGKM classification of stellar spectral types) and Cecilia Payne-Gaposhkin (who first showed that stars are mostly made of hydrogen). In the second half of her book, Bartusiak takes up the still unfinished search for the composition of the dark (that is, invisible) matter that makes up the vast majority of the mass of the universe. I think the best parts of the book are the "you are there" treatments of the hunt for brown dwarfs at a telescope and the search for dark-matter particles in an underground laboratory. However, the discussions of theories of candidate dark-matter particles, the techniques now being used to search for them and their astrophysical consequences are not very illuminating. And I regret to have to report that the book is marred by a few misleading or inaccurate statements, such as an unexplained remark that Copernicus did not need epicycles, the repeated claim that a universe of critical density will eventually stop expanding and the statement that "the physics community now seems to prefer rhyming *quark* with the word *mark*" (see N. David Mermin's amusing analysis of the correct pronunciation in PHYSICS TODAY, December 1993, page 9). But there are many great interviews, stories and quotes. I only wish the references were cited.

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Dynamics of the Standard Model

John F. Donoghue, Eugene Golowich and Barry R. Holstein
Cambridge U. P., New York, 1994. 558 pp. $39.95 pb
ISBN 0-521-47652-6

To be succinct, I like this book. In fact, I think you will too, if you are interested in the details of the standard model. This book devotes a lot of attention to aspects of the standard model that require an understanding of its dynamics and not merely its symmetries. These issues are very important for researchers, and the book is destined to become both a valuable reference for them and a text that can be used in advanced courses in particle physics. An audience that has already mastered particle physics at the level of, say, *Gauge Theory of Elementary Particle Physics* by Ta-Pei Cheng and Ling-Fong Li (Oxford, 1988), would be very well prepared for this volume.

The standard model of particle physics is consistent with all current experimental results in elementary particle physics. With the recent evidence for the top quark (see PHYSICS TODAY, June 1994, page 17), there remains to be found one anticipated particle, the Higgs boson, to complete the particle content of the model. Unfortunately, with the cancellation of the Superconducting Super Collider, we may have to wait longer to explore this issue.

Despite the successes of the standard model, there remain many undetermined parameters, mostly having to do with the couplings of the Higgs; those couplings determine the masses and mixings of the fermions. In the lepton sector, if the neutrinos have masses, this can lead to neutrino oscillations. In the quark sector, we have the Cabibbo–Kobayashi–Maskawa matrix, and for three or more generations the possibility of accommodating *CP* violation.

Although *CP* violation was discovered 30 years ago, we still do not know the details of the CKM matrix elements well enough to say that *CP* violation is explained. Much of the difficulty of determining CKM matrix elements from experiment is related to our lack of understanding of the strong dynamics that affects heavy quarks when they decay weakly as they reassemble themselves into observed hadrons; the detailed discussion of this and related issues is at the heart of this book.

Many important techniques are introduced and applied in *Dynamics of the Standard Model.* The book opens with three introductory chapters that cover gauge symmetry, the standard model and symmetry breaking via anomalies and other routes. Effective Lagrangians are treated in the fourth chapter, in which the authors do a wonderful job of explaining the philosophy of the effective Lagrangian approach and include several applications. Chiral perturbation theory, the operator product expansion, expansion in one over the number of colors, the Skyrme model, the bag model, potential models and quantum chromodynamics sum rules are all dealt with in subsequent discussion. Two final chapters deal with the physics of Higgs, W and Z bosons.

Two important tools of theoretical particle physics are not treated: the parton model and lattice gauge techniques. The parton model is a key component of applications of perturbative QCD. Because an important goal of this book is to deal with aspects of the standard model that are not amenable to treatment by perturbation theory, it seems reasonable to omit treatment of the parton model. As for lattice techniques, the authors explain in the preface that "the study by computer of lattice field theory is an extensive and rapidly changing discipline, which we do not attempt to cover." From my own point of view as a lattice gauge theorist, this is a justifiable position.

The three authors, John Donohue, Eugene Golowich and Barry Holstein, have made important contributions in a number of areas that are treated in this book. It is sensible of them to concentrate on areas of their own expertise. A young lattice gauge theorist who reads this book with the desire to find problems amenable to lattice techniques will be well rewarded by the effort. I heartily recommend the book.

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Critical Assembly: A Technical History of Los Alamos During the Oppenheimer Years, 1943–45

Lillian Hoddeson, Paul W. Henriksen, Roger A. Meade and Catherine Westfall
Cambridge U. P., New York, 1993. 509 pp. $39.95 hc
ISBN 0-521-44132-3

Critical Assembly joins a plethora of scholarly books and articles that examine the history of the World War II Los Alamos effort to build the first atom bomb. The authors acknowledge this at the outset, but they maintain that their story provides a new and more comprehensive approach to the technical developments at Los Alamos. This is because they draw upon a full lode of primary data and explore for the first time the methodology by which researchers at Los Alamos succeeded in their wartime mission. The authors successfully avoid the "official history" pitfall by focusing on individual contributions to scientific and technological advances as opposed to the usual summary of divisional achievements. The result is a well-documented, concise, chronological review of the combination of nuclear physics, chemistry and metallurgy that produced the first fission weapons. The volume also examines the impact of Los Alamos upon the methodology of "big science" at national laboratories in the postwar era.

Each of the authors of *Critical Assembly* makes significant contributions within each chapter: Lillian Hoddeson, a physicist and historian of modern science, was engaged by Los Alamos to coordinate production of the lab's history, and her contribution to this book is primarily in the area of implosion. Catherine Westfall, a historian of science at the Lyman Briggs School at Michigan State University, contributed reviews of pre-project history, chemistry, metallurgy and nuclear physics. Paul Henriksen, also a historian of science at Los Alamos National Laboratory, was responsible for reviews of the Trinity bomb test at Alamogordo, New Mexico, delivery systems, the lab as an institution and the town of Los Alamos. Roger Meade, the Los Alamos archivist, handled the early history and incorporation of archival materials.

A significant portion of *Critical Assembly* is directed at historians of physics, especially those interested in the Manhattan Project. The chapters examine the role of individuals whose contributions received only cursory attention in previous historical reviews. By necessity, much of the volume focuses on the more scientific aspects of the project, although certainly these activities highlight the key role of technology in promulgating big science. In this capacity, *Critical Assembly* complements Stephane Groueff's production-oriented history of the project, *Manhattan Project: The Untold Story of the Making of the Atomic Bomb*, (Little, Brown, 1967).

The role of Los Alamos in the rise of big science receives less attention in the book than is desirable, considering the authors' desire to place their story in a broad historical context. Los Alamos exemplifies the trial-and-error methodology that was so successful in large wartime projects such as the Manhattan Project and the development of penicillin and synthetic rubber. As such, it became a significant reference point for many of the postwar laboratories that benefitted from continued government support for big science.

At Los Alamos, a bond between science, engineering and the military was firmly established, and the enormous success at Los Alamos contributed to the strengthening of this bond in the post-World War II era. The authors provide all the detail necessary to examine the emergence of this relationship, but they do not place it firmly within the broader context of postwar US science and technology policy. This shortcoming does not de-