

of the first, provided the reader has both the background and the maturity to absorb the presentation, which is comprehensive and general.

Weinberg discusses the quantization of gauge theories starting with the work of Bryce S. DeWitt and of Ludwig D. Faddeev and Viktor N. Popov, going on to the BRST (Batalin–Rouet–Stora–Tyutin) method and further to the Batalin–Vilkovisky technique and the associated antifield and antibracket formalism. To find a discussion of these latter topics elsewhere, one must consult books dedicated to gauge quantization, such as *Quantization of Gauge Systems* by Marc Henneaux and Claudio Teitelboim (Princeton U. P., 1992). After the first three chapters on gauge theory and its renormalization using external field methods, Weinberg reveals a panoply of techniques employed to apply field theory to the standard model, including renormalization group methods, spontaneously broken global and gauge theories, effective field theories, operator product expansions and topologically nontrivial field configurations. Weinberg has made seminal contributions to many of these areas; the uniformity of presentation reflects his mastery of every aspect of the subject.

As a text for a first course on field theory applied to the standard model, *An Introduction to Quantum Field Theory*, by Michael E. Peskin and Daniel V. Schroeder, (See the review in *PHYSICS TODAY*, August 1995, page 69), takes a more elementary, less general approach and requires a less steep learning curve for the neophyte. Weinberg's *Modern Applications* goes to the boundaries of our present understanding of field theory. It is unmatched by any other book on quantum field theory for its depth, generality and definitive character, and it will be an essential reference for serious students and researchers in elementary particle physics.

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Time's Arrow and Archimedes' Point

Huw Price

Oxford U.P., New York, 1996.

306 pp. \$25.00 hc

ISBN 0-19-510095-6

Huw Price, a reader in philosophy at the University of Sydney in Australia, has written a book addressed to physicists, philosophers and general readers concerned with the perception and treatment of time in the formulation of fundamental physical theory. He

claims, quite correctly, that “philosophers as well as physicists often fail to pay adequate attention to the [asymmetric] temporal character of the viewpoint which we humans have on the world.” To overcome this human bias and achieve temporal correctness, Price advocates the “Archimedean view of reality . . . the view from *nowhen*” (recalling Archimedes’s boast that he could lift the whole Earth, given a fixed point outside of it and a long enough lever).

The first main theme of the book is that “the asymmetries of thermodynamics and radiation appear to depend on the fact that the universe had a particular character early in its history: Its matter was very evenly distributed, which is a very ordered [low entropy] condition for a system in which gravity is the dominant force.” Price then argues that, while this initial condition explains the observed macroscopic asymmetry, which includes our own biological and psychological makeup—the past feels very different to us from the future—it does not imply an additional microscopic asymmetry that physicists often mistakenly assume. This he calls μ Innocence: “Interacting [microscopic] systems are uncorrelated before they interact.” This leads to “a deep and almost unrecognized conflict in contemporary physics. If we are to retain *T* Symmetry, we should abandon μ Innocence.” Furthermore, “quantum mechanics seems to offer empirical confirmation that μ Innocence fails. The failure of μ Innocence seems to open the way for a kind of backward causation.”

A detailed discussion of quantum mechanics is in the last part of the book. After describing the usual paradoxes, Price comes down strongly in favor of what he calls “the common future hypothesis,” which is a denial of μ Innocence, or independence, to objects that have an interaction in the future. “Compared to all other major approaches, its advantage seems to be that it does not conflict with special relativity”—that is, it does not require the “crude” nonlocality that follows from Bell’s theorem when backward causation is excluded, because “the point at which [systems] become coupled . . . lies well within the light cone of their later [interactions].” In fact, Price advocates a local hidden-variable theory made compatible with quantum mechanics and special relativity through backward causation.

On the whole, Price does well in pointing out how the macroscopic asymmetries in our world are explained by the low-entropy initial state of our universe. This idea is, of course, not original to Price. It goes back at

least to Ludwig Boltzmann, and it was presented succinctly and elegantly by Richard Feynman: “It is necessary to add to the physical laws the hypothesis that in the past the universe was more ordered, in the technical sense, than it is today . . . to make an understanding of the irreversibility (*The Character of Physical Law*, MIT P., 1967).” Price does not quote Feynman but follows closely the recent, very clear formulation of this idea in terms of the Big Bang model described by Roger Penrose in *The Emperor’s New Mind* (Oxford U. P., 1989), where Penrose equates “initial state” with the smooth energy density state prevalent soon after the Big Bang.

To be able to make deductions from this smooth initial macrostate of the universe, one has to add, implicitly or explicitly, that the initial microstate was typical with respect to some (at least vaguely defined) weight or measure on the different microstates compatible with the initial macrostate, for example, “uniform” weight to all quantum states. Accepting this reasonable minimalist assumption, one should then be able to decide, at least in principle, what correlations are to be expected in particular situations; no additional independent assumptions about μ Innocence would then be necessary or possible. Of course, this might still require adopting, as practical working hypotheses, certain rules of thumb about correlations and causations, not only in our daily lives but also in our scientific work. This, and not some hidden “mistake,” seems to me the justification of the working assumption of the lack or irrelevance of certain correlations to which Price so strongly objects.

Price’s failure to deal with this makes his argument about the merits of backward causation as a viable explanation of our world unconvincing. What he suggests is not clearly wrong, and it certainly should not be dismissed out of hand. But Price doesn’t seem to appreciate the difference between having a general idea, which one can discuss at lunch, and actually providing a consistent physical theory, or even the outlines of one, which implements, in the form of equations, this backward causation. Lacking such a theory, he should have put forward his ideas much more tentatively. Whether a theory of this kind could really be made viable is another matter.

Still, despite many shortcomings and much arrogance, the book is worthy of attention. Price presents a good account of the conceptual problems present in our current view of the world, a world where results of measurements, as given by instrument

readings, are wonderfully and accurately predicted by quantum mechanics, but where the true nature of the reality described by the theory is so problematic that many physicists actually deny the existence of any reality on the microscopic level. His discussion in this connection of the Einstein-Bohr "debate" about the completeness of the quantum description of reality is better than that found in much of the physics literature. He hits the nail on the head when he writes, "The EPR [Einstein-Podolsky-Rosen] arguments failed by and large to sway supporters of the Copenhagen Interpretation, but this is perhaps due more to the obscurity of the Copenhagen response than to any compelling counterargument it brought to light."

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Modelling Molecular Structures

Alan Hindcliff
Wiley, New York, 1996. 256 pp.
\$29.95 pb ISBN 0-471-95923-5

The approach, the contents and the level of Alan Hindcliff's *Modelling Molecular Structures* are admirable. There are many beginning texts on the electronic structure of atoms and simple molecules and many introductory texts on quantum mechanics. Hindcliff's book approaches those aspects of molecular electronic structure necessary for working chemists, chemical engineers and materials scientists, and it does so in an informal, breezy, attractive fashion.

The intuitive, relaxed style of the book is refreshing, and the choice of topics is a fascinating one. In addition to standard electronic-structure ideas (hydrogen molecule ion, hydrogen molecule, self-consistent fields, electron correlation, density-functional methods, potential-energy surfaces), there are applications to molecular mechanics and molecular modeling as well as a program disk containing simple electronic structure methods and sample calculations.

I know of no other text with precisely this set of topics and with this simplicity and directness of approach. But there is a very serious, possibly destructive drawback: the book is full of errors. There are typographical errors as well as errors of definition and concept. The proofreading and copyediting were either not done at all, or done in an extremely sloppy way. For a teaching text, this is a disastrous situation; those who have been through

this material before can still profit substantially from the current text, but for first-time readers or students, I believe that the errors are simply too abundant and too misleading. For example, in chapter 2, the helium atom is given a ten-electron configuration, the exchange integral is defined incorrectly, and the dissociation of the hydrogen molecule in the simplest molecular orbital approximation is presented incorrectly.

A second, corrected edition of this book would be an excellent teaching and learning text. The choice of material, the exposition and the approach are unique and valuable.

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Blind Watchers of the Sky: The People and Ideas that Shaped Our View of the Universe

Rocky Kolb
Addison-Wesley, Reading, Mass., 1996. 338 pp. \$25.00 hc
ISBN 0-201-48992-9

The fascination of cosmology long ago lured Fermilab's Rocky Kolb from his home in particle physics. One might then have expected his first book to be about the remarkable wedding, some might say shotgun marriage, of astronomy and particle physics in the quest for the ultimate laws of nature and the expression of those laws in the first femtosecond of the Big Bang. But Kolb is determined, in *Blind Watchers of the Sky*, to tell us about another of his passions—the scientific process, which is, in his view, not the method per se but rather the very human sequence of discovery and comprehension of the way our universe is put together. And his subject is not so much the modern descriptions of the physical universe, but rather those of the icons of historical astronomy: Galileo Galilei, Tycho Brahe, Johannes Kepler, Nikolaus Copernicus, Isaac Newton, William Herschel and Edwin Hubble, and of their heroic and sometimes failing struggles to make sense of what they observed.

The book's best feature is its attempt to bring these great scientists to life, to tell us enough about their lives and times so that we can better understand their view of the universe. The personal profiles are well researched and contain relevant material, not gratuitous gossip. And Kolb has many slants and opinions to share on their lives.

He concludes, for example, that Ke-

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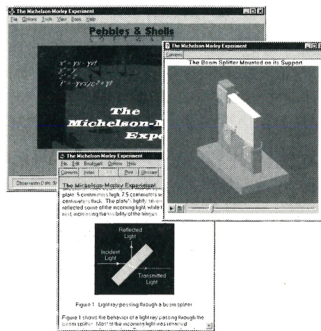
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