

ing 350 pages deal with topics that we also discussed. Kaku's book is well written, attractively formatted and has very few misprints. I am certainly impressed that one author was able to produce such a work in a short time while remaining active in research. Still, I have misgivings, which should be pointed out.

There are 36 pages on multiloop amplitudes. This is only sufficient for a very brief introduction to some of the important concepts. It certainly cannot go into any depth. Eric D'Hoker has written a review article of ten times this length (to be published in *Reviews of Modern Physics*), which is recommended for the serious reader. String field theory is the topic in which Kaku has the greatest expertise. The chapters on light-cone and Becchi-Rouet-Stora-Tyutin approaches cover standard material that a serious student of string theory should be familiar with. The chapter "Geometric String Field Theory" describes an approach that Kaku has developed recently. It has not received attention from other experts, so its value is still uncertain.

The book's 350 pages that are devoted to topics that we covered in our book follow our notation, conventions and overall treatment quite closely. By condensing the coverage by a factor of more than three, Kaku has sacrificed much discussion and explanation. I doubt that it is possible for a student to learn the subject from such a brief treatment.

In conclusion, this book is an impressive effort to give a more up-to-date treatment of string theory. Its fundamental flaw is that it covers too many topics too concisely. It is a pity that Kaku did not expand the chapters on string field theory by a factor of three and make those into a separate book.

JOHN SCHWARZ

California Institute of Technology

A Brief History of Time

Stephen W. Hawking

Bantam Books, New York,

1988. 198 pp. \$18.95 hc

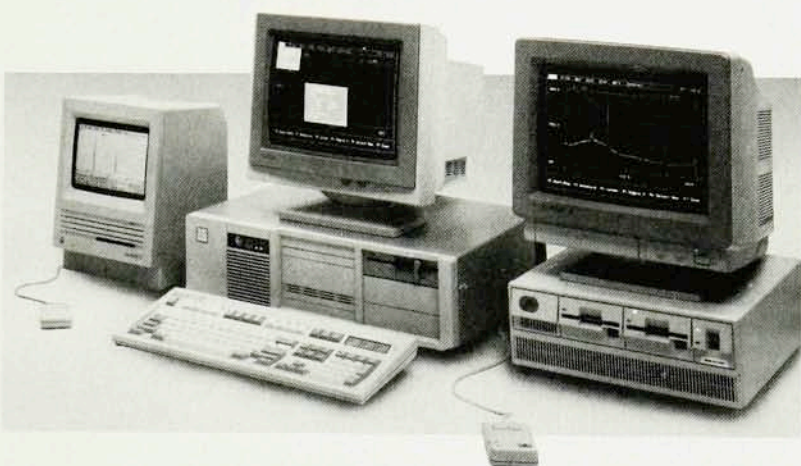
ISBN 0-553-05340-X

Can a popular book on science, one which has remained in first place on the *New York Times* nonfiction best-seller list for many months, be of more than passing interest to the readers of *PHYSICS TODAY*, most of whom are professional physicists? If the book is Stephen Hawking's *A Brief History of Time*, the answer is a definite yes. Hawking has succeeded in writing two intertwined books, one

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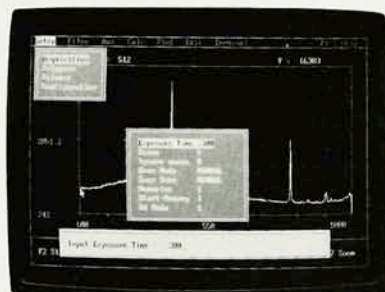


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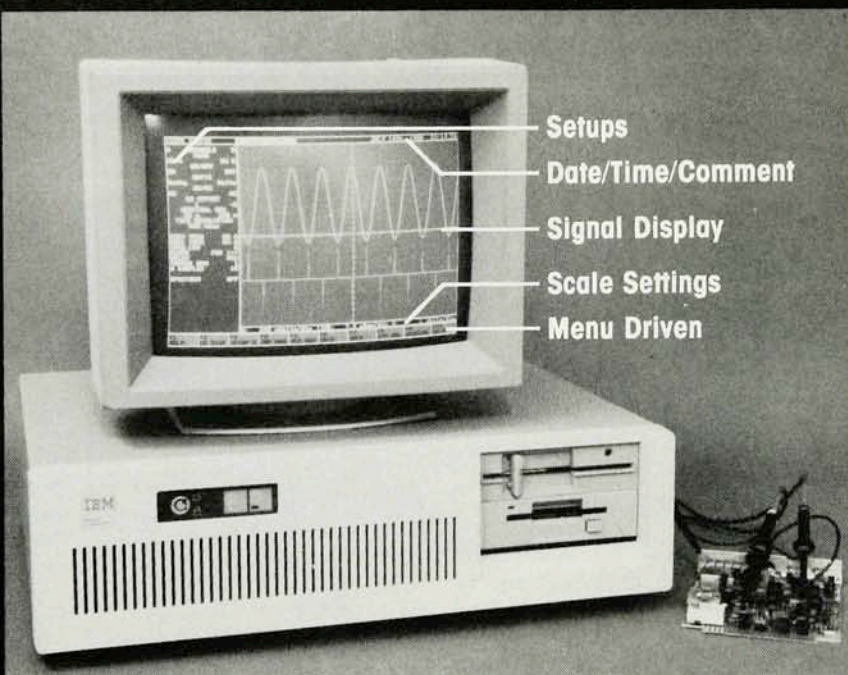
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a highly readable and entertaining popular account of the role of time in physics, the other an in-depth review of the most recent developments in cosmology, elementary-particle theory, quantum gravity and their interrelations. It is this latter book that can be recommended to any physicist who would like to know what is going on in these fields today. In addition there are numerous autobiographical notes and inside stories that will be of interest even to the experts.

Hawking is one of the leading theorists of our time. He now occupies the same position at Cambridge once held by Newton and later held by P. A. M. Dirac. The work of Hawking and Roger Penrose, another great English theorist, on singularity theorems settled once and for all the question of the existence of a Big Bang in general relativistic cosmologies (it cannot be avoided) and his work on black hole thermodynamics opened a new era in black hole physics. His current interests are focused on the origin of the universe and the unification of general relativity and quantum mechanics. It is these latter subjects, and especially his contributions to them, that are of most concern to him in this book.

The first half of Hawking's book contains material that, for the most part, will be familiar to readers of *PHYSICS TODAY*, containing as it does a brief history of the evolution of our ideas of space and time, and an introduction to quantum mechanics, cosmology and elementary-particle physics. Some of the discussions are short indeed. There is a breathtaking tour of the whole of stellar evolution in two pages, and all of Earth's history, including its biological history, is covered in one long paragraph. In spite of its brevity I nevertheless found Hawking's account to be illuminating. His description of the Doppler effect is a small gem, and his discussion of entropy is as good as one is likely to find today in a popular account. His history, on the other hand, is perhaps a bit too abbreviated. He does not, for example, give proper credit to Ralph Alpher and Robert Herman for their prediction of the cosmic blackbody background radiation (see Alpher and Herman's article in *PHYSICS TODAY*, August, page 24), and in my opinion he also slights the contributions of Johannes Kepler to the scientific revolution of the 17th century.

It is the second half of Hawking's book, however, beginning with an excellent account of black hole physics, that should be of interest to the nonexpert. There is, for example, an

extremely lucid description of inflationary cosmological models in the chapter on the origin and fate of the universe. In one short paragraph Hawking describes why Alan Guth's old inflationary model was fatally flawed and how the new inflationary models of Andrei Linde and of Paul Steinhardt and Andreas Albrecht overcame these difficulties. We also learn that in Hawking's opinion the new inflationary model is also dead scientifically and has been superseded by a chaotic inflationary model due to Linde. (See Linde's article in *PHYSICS TODAY*, September 1987, page 61.)

Much of the material in the second half deals with Hawking's own contributions to black hole physics, cosmology and quantum gravity. The chapter entitled "Black Holes Ain't So Black" describes in considerable detail his discovery of what is now known as Hawking radiation and his contributions to black hole thermodynamics. In a later chapter he discusses his Feynman sum-over-histories approach to quantum gravity, the use of imaginary time to evaluate such sums and his proposal, in connection with these ideas, that "the boundary condition of the universe is that it has no boundary." (One wonders a bit what the general reader must make of some of this material.)

What makes all of this so interesting is Hawking's ability to convey the essential physics in words alone (there is only one equation in the whole book). The exposition is usually so clear that one feels the missing equations can be derived with just a bit of effort. In several instances the presentation is even clearer than it is in the original journal article. The only complaint one might have is that there is no bibliography, so the reader cannot easily locate original sources. But for this reader, the best thing about the book is the many questions of principle Hawking raises. One may not always agree with his answers or speculations, but one feels challenged by them and wishes Hawking were present to carry on the discourse.

JAMES L. ANDERSON
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Quasars, Redshifts and Controversies

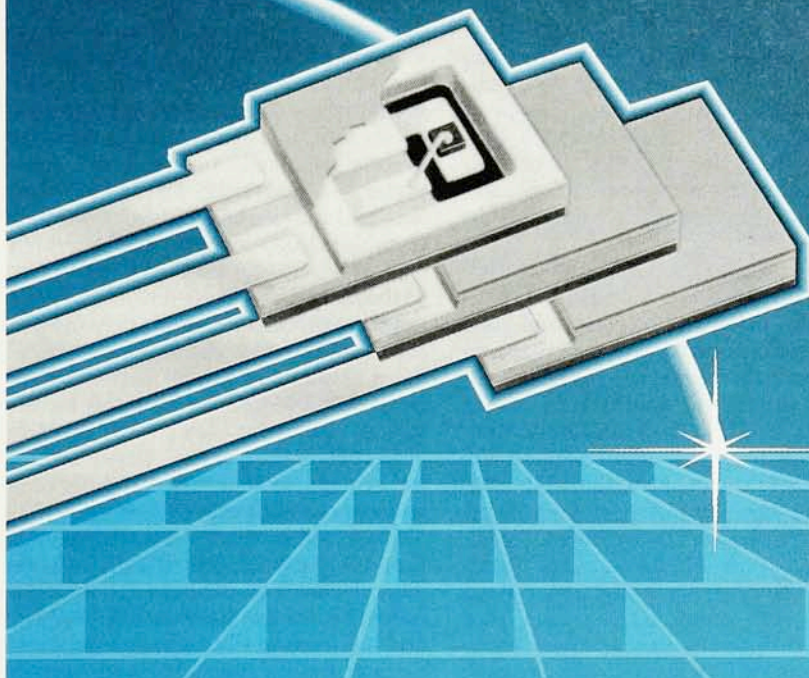
Halton Arp

Interstellar Media, Berkeley,
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