implanted layers (L. Csepregi, J. W. Mayer and T. W. Sigmon, *Phys. Lett.* **A54** 157, 1975). These are some of the prettiest demonstrations of ion implantation and channeling techniques, now leading to an understanding of the crystal-amorphous interface.

The authors are quite cognizant of the fact that they have omitted the burgeoning subject of implantation into materials other than semiconductors. Ion implantation has been successfully employed to modify the properties of superconductors, optical materials, catalysts and surfaces that are subject to wear or corrosion. Any property of matter that is surface-sensitive is fair game for implantation. Although the technological importance of implantation in these areas has not been established, there is no doubt that some of the science is taking shape. For example, ion implantation is a highly non-equilibrium process, and in the past year connections have been established between metastable alloys produced by ion implantation and those formed by the more conventional rapid quenching techniques such as splat-cooling.

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Space and Time in the Modern Universe

P. C. W. Davies
232 pp. Cambridge U. P., New York, 1977.
$13.95 clothbound, $5.95 paperbound

As is stated on the cover, this book will appeal to undergraduates both in and out of the physical sciences, as well as to scientists and philosophers who would like to review some modern developments on such topics as time reversal and quantum ideas associated with black holes.

At first sight one might ask, "Who needs another elementary account of space and time, especially with a preface that explains powers of ten?" However, P. C. W. Davies, who is a lecturer in applied mathematics at King's College, London, demonstrates in the first few pages that he is a professional. His knowledge of modern physics together with the clarity of his writing produce an excellent non-mathematical book of the sort one might use for popular-type (but serious) courses in "The Nature of Time" and similar topics. (At New Paltz, for example, we have such a freshman course, which has been quite popular for four years now.)

Very briefly, the first two chapters deal with the absolute space and time of Newton and how these two apparently different entities were seen, in special relativity, to be part of a higher entity. In chapter 3 Davies asks why some things—such as atoms—seem to persist in their motions, clock-like, whereas people die and cars rust. He considers time asymmetry (compare the harmonic motion of a simple pendulum, for instance, with the irreversible behavior of a lighted match) and goes on to a non-mathematical discussion of the Boltzmann H Theorem.

Davies then examines space and time from the point of view of a freely falling observer (chapter 4), along with the principle of equivalence and the distortion of space-time by gravity. While discussion of such material normally makes no contribution to the average physicist's knowledge, the account is commendably well written, especially for people who (thus far) have only vague ideas about such material. Davies includes space-time in collapse, and of course he goes on to the "old-hat" subject of black holes and the Schwarzschild radius. But there is an excellent section on quantum ideas in general relativity and on Stephen Hawking's work on thermodynamics, on singularities, and on the quantization of the gravitational field.

The last three chapters of the book look in a challenging way at stability and instability in the universe, the three basic Friedmann cosmological models and Mankind's existence. There are very interesting short discussions of the Wheeler–Feynman absorber theory and of order and disorder in the universe, with examples drawn from Thomas Gold's ideas on recontracting Friedmann universes and John Wheeler's speculations on a gradual changeover in direction of time-asymmetric processes.

In the cosmology chapter's section on *non*-standard cosmologies, I do have a minor complaint: There was no mention of the Gödel rotating models. I would also object that this book on time makes no mention of "chronons."

The last sections of the book include sensible discussions of exobiology ("to date no subject matter . . . !"), why the universe is "big," religion, and mind and perception in the universe. Altogether, a very interesting book.

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The Structure of the Universe

J. Narlikar
264 pp. Oxford U.P., New York, 1977.
$12.00 clothbound, $4.50 paperbound

In the past few years there has been a tremendous explosion of interest in the subject of cosmology; the origin, evolution and nature of the universe in which we live. This explosion has been stimulated by observational discoveries ranging from quasars, pulsars and x-ray sources to the universal background radiation. Closely

coupled with this increased interest in the universe, as a whole, has come a plethora of books on the subject, ranging from popular monographs, to introductory text books for nonscience majors, to somewhat more advanced works. To this growing list of publications must now be added Jayant Narlikar's book *The Structure of the Universe*. Narlikar is professor of astrophysics at the Tata Institute of Fundamental Research in Bombay, India. He established his reputation in astrophysics working with Sir Fred Hoyle in Cambridge, England, where he was one of the last defenders of the steady-state theory of cosmology and where he developed the Hoyle–Narlikar theory of cosmology.

Narlikar's writing style is a nice blend of oriental story telling, combined with precise English commentary. The extended quotes that begin each chapter are highly captivating.

One aspect of this book makes it particularly difficult to review; it is not clear for what audience it is written. Since it does not have homework problems, and so on, it does not appear to be a text book. Because the main-line presentation does not contain any mathematics, it is presumably written for a "lay" audience or for supplementary reading in an introductory course. However, there are boxes where algebraic derivations are presented, and the language of the text, although not containing equations, does get rather intricate and technical at times. Thus it would probably be rather difficult for the layman to comprehend without a good deal of effort. Perhaps the best audience is really the scientist or engineer who is not active in the field of cosmology, but does have sustained interest in the field. Such a person would find the book relatively easy to read and would thus be able to learn Narlikar's views on cosmology.

It should be noted that most of the recent books that have been written on cosmology have been written with the belief that the implications of much of the recent astronomical data seem to direct one to a cosmological model not too different from the so-called "Standard Big Bang Model." In my opinion the best of these books is Steve Weinberg's *The First Three Minutes*, where a "Scientific American" level presentation is given of the standard model and its observational motivations. Narlikar, however, is one of the only cosmologists who still actively support steady-state theory. (Even Fred Hoyle, to whom the book is dedicated, now talks in terms of some sort of Big-Bang type of model, although admittedly a very nonstandard Big Bang.) Because of this different viewpoint, Narlikar's book is somewhat unique for a book written in 1977. A balancing of a steady-state and Big-Bang viewpoints was common for books written in the 1950's and early 1960's, but this is no longer the case. This unique view of a continuing steady-state–Big-Bang controversy produces comments and questions, which to many people may seem heretical. Seeing how one of the last of the steady-state defenders rationalizes the present overwhelmingly pro-Big Bang 3 degree black-body radiation observations is certainly quite intriguing.

The book starts out discussing stars, black holes, supernovae and the origin of elements in stars. Although only one chapter is devoted to stellar topics, coverage of a tremendous amount of information is attempted. It is very unfortunate that the brief but detailed discussion of the origin of the elements in stars is outdated and ignores the developments of the last decade on supernovae and explosive nucleosynthesis and instead dwells on 1950's terminology.

The book rapidly shifts to galaxies and cosmology, revealing that the book really is going to concentrate on the cosmological questions. The questions that are brought out emphasize topics which some in the astronomical community may ignore or feel are already solved. These range from questions such as local versus non-local origin for quasars, non-cosmological interpretations of red shifts, time variations in the gravitational constant and the origin of the arrow of time

to the need for new laws of physics. Because very few of these questions are brought up in the other recent cosmology books on the market, it is very nice to see them all gathered together in one place. However, there is a danger that if somebody only reads this book and not any of the other cosmology books, he would end up getting a distorted view of how the majority of astronomers and astrophysicists feel about many basic questions. Very few cosmologists still consider the major question in cosmology to be the resolution of the debate between the Big-Bang theory and the steady-state theory. Most are reasonably well convinced that the universe did undergo some sort of Big Bang. There is of course a danger in science of a "band-wagon" effect carrying people over objections when the facts are not really there; however, one has to work pretty hard to get around, simultaneously, the microwave-background observations, the universal helium abundance, the deceleration-parameter observations and the current radio-source counts.

Many of the questions brought out in the book would have been standard if the book had been written in the 1960's when these matters were much debated, but for a book published in 1977 it is somewhat unique.

In summary I would not recommend this as a first book in cosmology (or for that matter even a second). However, for someone who has read and enjoyed *The First Three Minutes* this might make an interesting and extended counter point showing that even in 1977 not quite everyone is completely enthralled with the "conventional wisdom."

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new books

Crystallography, Low-Temperature and Solid-State Physics

Liquid Crystals. S. Chandrasekhar. 342 pp. Cambridge U. P., New York, 1977. $38.50

Viskoelastizität und Plastizität: Thermomechanisch Konsistente Materialgleichungen. P. Haupt. 208 pp. Springer-Verlag, Berlin, 1977. DM 32.00 ($14.10)

Diffusional Creep of Polycrystalline Materials. B. Burton. 119 pp. Trans Tech, Bay Village, Ohio, 1977. $26.00

Solid State Devices 1976 (Papers presented at the 6th European Solid-State Device Research Conf., held at the Technische Universität, Munich, September 1976). R. Müller, E. Lange, eds. 140 pp. The Institute of Physics, London, 1977. £13.00 ($25.00)

Radiation Effects in Semiconductors 1976 (Papers presented at an Int. Conf. held in Dubrovnik, Yugoslavia, September 1976). N. B. Urli, J. W. Corbett, eds. The Institute of Physics, London, 1977. £22.00 ($42.00)

Astronomy, Cosmology and Space Physics

Space Chemistry. L. Nikoaev. 198 pp. Mir, Moscow (US distributor: Imported Publications, Chicago), 1976 (Russian-language edition, 1974). $2.00

Bicentennial Space Symposium (Advances in the Astronautical Sciences, Vol. 35). W. C. Schneider, ed. 229 pp. American Astronautical Society, San Diego, 1977. $25.00

The Inner Planets. C. R. Chapman. 170 pp. Scribner's, New York, 1977. $7.95

Apollo Soyuz Mission Report (Advances in the Astronautical Sciences, Vol. 34). C. M. Lee, ed. 322 pp. American Astronautical Society, San Diego, 1977. $35.00

Supernovae (Astrophysics and Space Science Library, Vol. 66—Proc. of a special IAU session, Grenoble, France, September 1976). D. N. Schramm, ed. 192 pp. D. Reidel, Boston, 1977. $22.00

CNO Isotopes in Astrophysics (Astrophysics and Space Science Library, Vol. 67—Proc. of a special IAU session, Grenoble, France, August 1976). J. Audouze, ed. 195 pp. D. Reidel, Boston, 1977. $22.00