Cosmology without Tears

The Mystery of the Expanding Universe. William Bonnor. Macmillan, New York, 1964. xii + 212 pp. Illus. $7.50.

It is rare indeed that a publisher's blurb accurately describes the work it advertises. But in this case, "humorous, caustic and illuminating" perfectly characterize William Bonnor's book. One might also add that his exposition is a model of lucidity, is always exact, and is as simple as the complex subject of cosmological theory permits. Though the work is intended for the intelligent layman, there is hardly a chapter which the professional cosmologist will not find instructive.

A sketch of the observational data occupies the first five chapters and, in these, Bonnor's masterly analysis, in simple terms, of the notion of distance, and of the many pitfalls that are contained in this notion, is particularly noteworthy. The next five chapters deal with the models of the universe which are deduced from general relativity. Here a refreshing departure from tradition is made. Instead of concentrating on the Einstein and de Sitter universes, neither of which fits the observations, Bonnor begins with three models that contain both matter and motion. These are the models derived from the assumption that the cosmical constant is zero. He is particularly good on the initial singular state—the Big Bang—from which the expansion in these models begins. He explains how this condition is a result of the oversimplification of the physical situation inherent in the models and how dangerous it is to identify the singular state with an act of creation carried out by God. Models with a positive cosmical constant are also described because Bonnor believes that the presence of such a constant would account for the expansion through a cosmic repulsion. He does not refer to models with a negative cosmical constant which, in my own opinion, would explain the retardation of the expansion suggested by the data obtained in the last ten years. Gödel's "rotating" model of the universe is given a most illuminating chapter to itself. Finally, an analysis of the steady-state theory leads to the conclusion that it is a phenomenological scheme, perhaps capable of describing the expansion phenomenon, but otherwise devoid of a proper theoretical foundation. In the last two chapters Bonnor summarizes the position in the light of Baum's optical data and of the radio astronomical observations made by Ryle and others. Bonnor comes out in favor of some one of the general relativity models, and he thinks that the steady-state theory has a rather doubtful future in front of it.

A reviewer ought to find something to criticize in a book, if only to show that he has read it. I have had some difficulty in finding anything and can only point to one or two matters of detail. Bonnor is a mathematician and, as he says himself, primarily a theoretician. I therefore read with surprise (p. 129) that, with a nonzero cosmical constant, the "problem [of solving Einstein's equations] becomes preposterously difficult." In fact, the increase of difficulty is trifling, at least in the cosmological problem. An elliptic integral of the first kind has to be dealt with instead of elementary integrals that lead to trigonometric or hyperbolic functions. The explanation of Bonnor's statement is not to be found in the supposition that I am a better mathematician than he is. For he implies (p. 170) that he can follow Sciama's mathematical treatment of the formation of galaxies in the steady-state theory, a piece of analysis that has hitherto entirely defeated me.

A theoretician may perhaps be allowed to lay less emphasis on observation than on theory. It is, however, unfortunate that Bonnor writes of Baade's 1952 revision of the cosmical distance scale (p. 33) as the correction of a "mistake" made by previous observers. An error in algebra is suggested, or at least an obvious misinterpretation of the available data. In fact Baade's revision was due to the acquisition of new data that were not available to his predecessors. As I read the story, it was the realization that Cepheids fell into two classes (Populations I and II), rather than the correction of errors in statistical parallaxes, that produced the change. The revision of the distance-scale constitutes an example of the fact that, as knowledge increases, conclusions have to be altered. It is also unfortunate that Bonnor lays so much stress on Baum's observations, compared with Sandage's photographic data, in the velocity-distance problem. Baum has never published a detailed account of his methods or of his data, particularly with respect to the crucial apparent magnitudes he finds. All that has appeared is a small-scale graph or two of his results, accompanied by statements of the conclusions he draws from the unpublished observations. I am said to consider that it is "improper" to assume the existence of unobserved and unobservable matter in the universe (p. 44). The average density quoted on page 203 is, I would say, at least 40 and probably 100 times too high. It would mean that astronomers have so far only identified matter, either luminous or nonluminous, to the extent of between 1 and 3 percent of what is there. The presence of the remainder is needed to force agreement with one of the simple models of the universe. I can see little difference between this procedure and the introduction of God to account for the singular state to which Bonnor objects in chapter 8.

These are, however, criticisms of minor details. Bonnor's book should be, I believe, required reading on the part of all students of cosmology. Relativistic cosmology has long needed a brilliant popularization to serve as an antidote to the equally brilliant popularizations of the supporters of the steady-state theory. Bonnor has now filled that need.

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Geology

Determination des Mineraux des Roches au Microscope Polarisant. Marcel Roubault and others. Editions Lamarre-Poinat, Paris, 1963. 365 pp. Illus. Plates. F. 48.50.

Twenty-five years ago Roubault, the senior author, collaborated with Leon Bertrand in writing an introductory textbook on the polarizing microscope, but this is not a revision of his earlier volume. Roubault, with his collaborators, has produced an entirely new text, which is divided into three parts. In part 1 (98 pages), the polarizing microscope is described and its use discussed. This is followed by a rather clear discussion of symmetry and crystals. Crystallogy is explained along with the necessary notations. In addition to the Miller indices we find those of Haüy-Lévy given, and both are used throughout the book. The treatment of optical crystallography provides a fair amount of detail on the various optical properties of crystals and how to recognize them.

Part 2, approximately two-thirds of the text (182 pages), deals with the characteristics of rock minerals. After a few general remarks and a short discussion of the silicates, the following groups are considered: silicates, feldspars, feldspathoids, micas (including talc and pyrophyllite), chlorites and clay minerals, pyroxenes, amphiboles, peridotites to serpentine, carbonates, sulphates, hydroxides, and a group of incidental minerals—silicates, phosphates, tungstates, and the like, with about six pages devoted to the uranium minerals (both primary and secondary). With each group there is an unnumbered table that gives the principal optical characteristics of the species in that group. Part 3 (36 pages) covers in some detail various methods of study and describes the observation of mineral sections as well as their analysis and the interpretation of the entire process. There are five synoptic tables—three deal with minerals, and two are indexes. A few recent developments, both here and abroad, are not considered, but I do not feel that this limits the volume's usefulness in a beginning course on the use of the petrographic microscope.

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Physics and Space Research

Gravitation and Relativity. Hong-Yee Chiu and William F. Hoffmann, Eds. Benjamin, New York, 1964. xxxviii + 353 pp. Illus. $15.75.

Until Einstein's death the weight of his personal authority was instrumental in determining the position and aims of the general theory of relativity as a branch of physical theory. Since that time the quickened emphasis on space research has forced the theory into the public domain for a number of groups of scientists and has resulted in wide-ranging discussion of its meaning and implications. This universe of discourse stretches from the traditionalists seeking to understand Einstein's physical ideas more fully, through the pure mathematicians interested primarily in theories of manifolds and differential equations, and on to the enthusiastic optimists in search of new pathways and a breakthrough to the Promised Land. The present volume, which represents the fruits of a seminar on the subject held in 1961 and 1962 under the auspices of the Goddard Institute for Space Studies, seems to be primarily an expression of the views of the latter group.

The book consists of 15 chapters by a total of six authors, together with an introductory article by the editors who attempt to provide a mean platform for the discussion. The individual chapters vary widely in purpose and in scholarly content, clearly being much influenced by their origin as seminar material. In a very rough classification the chapters by Anderson are expository in character; those by Dicke and by Weber are speculative on the experimental side; while those by Wheeler and Marzke are speculative on the theoretical side. Hughes discusses, in a somewhat more conventional manner, current ideas and experiments on mass (directional) isotropy in the universe and the equality of positive and negative electrical charge.

It is not the function of a reviewer to impose his personal views on the authors or the readers of a book. In the present case, however, the diverse and somewhat dithyrambic character of the different chapters makes an effective review of their contents difficult in the conventional sense. For this reason the purposes of the reader of this review may be as well served by an attempt to bring the discussion into focus within the context of a single point of view—that of the reviewer.

A basic problem that has been with us since the formulation of Einstein's theory in 1916 has been whether it represents a fundamental theory of time and space, or whether it is a theory of the influence of gravitational fields on the physical measurement of these quantities. In one way or another all of the chapters of this book stem from this problem and are limited by it. Therefore it is not unexpected to find oneself confronted throughout the volume with the usual variety of arguments that jumble together in an uncritical way ideas from Maxwell's linear theory of the electromagnetic field, Newton's linear theory of the gravitational field, and Einstein's nonlinear theory. Some attempt to sort out these ideas is made by Wheeler, but, although his arguments are interesting and explanatory, they do not seem to me to advance the problem much further toward resolution. The possible connections of Einstein's theory with quantum field theory, which are discussed by Anderson, are clouded by the difficulty that neither of the theories concerned has yet been given a sufficiently stable mathematical framework to sustain the attempt to weld them together.

In brief, I would recommend this volume to the sophisticated reader who can enjoy the liveliness of its approach and may even profit from stimulation by some of the ideas expressed. But it is not for the beginner who seeks enlightenment, nor for the mature scholar in quest of more profound analysis of difficult questions of principle.

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Introductory Textbook

Geology. William C. Putnam. Oxford University Press, New York, 1964. xii + 480 pp. Illus. $10.95.

The strongest impression that this book made on me was that a tremendous effort is involved in writing a good introductory text in geology. That effort is displayed by the abundant references, the excellent illustrations and photographs (which were chosen by his colleagues after the author's death last year and one of which is used on the cover of this issue of *Science*), and a careful exposition of the history of thought concerning each of the major subjects treated. In these areas this book is almost unrivaled in the field of geology.

The wit displayed here is in pleasant contrast to that in most geology textbooks. One can almost hear the chuckle from the classroom as Putnam slips in another witticism, with even the more cynical students enjoying it despite themselves.

Certain features of the book appeal to me less. Terms are carefully introduced in such profusion that, in some places, the text is encyclopedic; this tendency in recent textbooks disheartens me, although I appreciate its appeal to many. Putnam has made an earnest attempt to indicate the controversial nature of geology by leading the reader through discussions of diverse theories for the origin of such features as coral atolls, pediments, submarine canyons, and limestone caverns. He carefully notes that the final