clude 7 that were among the top 20 in the earlier period and 13 that have come up from somewhat lower ranks. More important than the changes in relative position of individual institutions are the changes in characteristics of the institutions that are most productive. Since 1946, liberal arts colleges, universities, and technological institutes of comparatively high cost have trained relatively more students who continued into graduate work in the sciences than have those of lesser cost. Twenty to thirty years ago schools of moderate cost were more productive than either the cheapest or the most expensive ones. Since 1946 schools in New England and the East North Central region have been the most productive ones. In the earlier period those in the Middle West and Far West were the most productive. A feature which stands out as characteristically in the recent period as it did earlier is the higher productivity of private nondenominational colleges and universities over public and denominationally controlled ones.

The GI Bill, the establishment of much broader scholarship programs by some of the older and wealthier (and incidentally Eastern and more expensive) institutions, and the higher general income level, the authors suggest, have probably been responsible for the shift in the center of gravity from Midwestern and Western institutions of moderate cost to Eastern institutions of higher cost.

Unlike the earlier book, this one also considers the undergraduate origins of young scholars in the humanities and social sciences. In general, the trends in these two areas are similar to those that have been mentioned for science students. Inclusion of information on all three areas, however, permits some interesting comparisons. Some of the schools which are most productive of future scientists also rank high in the undergraduate preparation of future social scientists and humanists. In fact, there are 8 institutions that rank among the top 20 in productivity in all three areas: Swarthmore, Reed, Chicago, Harvard, Oberlin, Antioch, Carleton, and Princeton.

One of the most challenging problems posed by the findings of this study is the relatively small number of undergraduate institutions which send significant numbers of their students into graduate work in the scientific and scholarly fields. Writing of the young natural scientists, Knapp and Greenbaum report that only some 60 institutions show "significant and impressive rates of production, while among the remainder the dedicated young scholar is a rare exception among their graduates." Students who have gained distinction in graduate work in the social sciences come from a somewhat smaller undergraduate base, and those in the humanities from a still smaller base and one that is sharply concentrated in the northeastern section of the country. It is good that there are institutions which stand out well above the level of intellectual stimulation of the average American college, but how far is it desirable to concentrate the source of graduate students in a small number of undergraduate institutions and to have those as geographically concentrated as has been the case since 1946?

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## Astronomy

*The Expansion of the Universe.* Paul Couderc; trans. by J. B. Sidgwick. New York: Macmillan, 1952. 231 pp. + plates. $6.00.

This highly readable book gives both the professional astronomer and the interested layman an account of the various data which led to the conception of an expanding universe. The book was awarded the Paul Pelliot Prize and the Henri de Parville Prize of the Académie des Sciences in 1950 and is excellently translated by J. B. Sidgwick.

After three introductory chapters dealing, respectively, with the observational data of our universe, the measurement of astronomical distances, and the distances and recession of galaxies, the author discusses in Chapter 4 the non-Euclidean space-time of general relativity. In Chapter 5 he treats the cosmological problem, in Chapter 6 the static universe of Einstein and the pseudo-static universe of de Sitter, and in Chapter 7 the expanding universe. Chapter 8 is devoted to a discussion of indications of a singular state of affairs about 4–5 billion years ago.

The book is very well written and can be read with profit by the interested layman—provided he is willing to read thinkingly—and it can be highly recommended.

There are a few minor points where, in my opinion, the book could be improved. The source of none of the excellent photos of galaxies is given. The Hertzsprung-Russell diagram is referred to as the Russell diagram (p. 39). The light deflection during an eclipse is *not* in accordance with the present predictions of general relativity and can scarcely be taken as a support for the theory of general relativity (p. 120).

Couderc goes to great length to prove that Lemaître's model fits the observational data, and he presents a strong case in favor of this. It is therefore to be regretted that the way in which he attacks other explanations is so often unnecessarily pugnacious, and even sometimes slightly malicious. This is the more surprising as Couderc mentions Omer's results of calculations regarding a nonhomogeneous model of the universe. From Omer's calculations one sees that the introduction of even a slight inhomogeneity can alter various results very considerably, and it seems to me that one must be extremely careful in adhering too rigidly to results obtained from a homogeneous model.

The case for the existence of a hyperdense state of the universe about 4 billion years ago has, to my mind, not been made. I agree immediately that all the evidence of Couderc's Chapter 8 points to a short time

scale, but this does not necessarily involve a hyper-dense state. The work of Hoyle, van Albada, and Klein and collaborators has shown, so far as I can judge, that nuclei of high atomic weight could also have been formed in essentially present-day stars, without making an over-all high density necessary.

These objections are minor, and one can only be grateful to Couderc for presenting us with such a colorful account of this subject.

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## Physics and Mathematics

***Cloud Chamber Photographs of the Cosmic Radiation.*** G. D. Rochester and J. G. Wilson. New York: Academic Press; London: Pergamon Press, 1952. 128 pp. + plates. $10.80.

Professors Rochester and Wilson, of Manchester, England, have been prominent in the development and exploitation of the cloud chamber technique. In the present volume, they give a well-rounded selection of photographs obtained in cosmic ray laboratories all over the world. Explanatory captions are included, but it is characteristic that the elementary principles of cloud chamber operation and particle behavior are not outlined. Indeed, the language of the captions will be meaningful only to those readers well initiated in cosmic ray research.

This is not so of the pictures ,however. They give a refreshing sense of reality to the existence and wonderful behavior of elementary particles possessed with fantastic energy; and persons in many walks of life may be led to feel a vivid appreciation of the extraordinary phenomena portrayed. Such visual comprehension is of great value to research workers, but it is not to be decried in the form it takes in those less fully informed. Even the feeling engendered that one has actually seen cosmic rays, is not unjustifiable, for one senses all objects with essentially the same sort of indirectness.

To a student of cosmic rays a careful reading of the captions, with frequent reference to the pictures under discussion, will be thoroughly rewarding. Mental exercise is required, since the explanations are necessarily abbreviated; but in the interpretation of the pictures here displayed, almost all the known laws of behavior of high energy particles and the properties of practically all the known particles are illustrated and put to use. Thus, following the arguments of interpretation can be of as much educational value as, for instance, the study of the recorded games of experts is to the student of chess.

Many of the pictures were apparently selected for their historical interest. These include the earliest photographs of cosmic rays by Skobelzyn, those of cascade showers by Blackett and Occhialini, the photograph by Anderson, credited with the discovery of the positron, some of the earliest records of mesons and their decay, and the first pictures of V-particles by Rochester and Butler. Such examples are also of educational value, because they demonstrate so effectively the process of discovery.

Other photographs are illustrative of the processes of interaction and transformation that have been studied in the cosmic rays, special emphasis being given to phenomena under current investigation. There are also pictures illustrating the distinctive properties by which different particles may be recognized. And another group of pictures was selected to show characteristics of the technique of cloud chamber operation, together with some of the many variations of apparatus and technique that have been employed for special purposes.

In almost all the commentaries, attention has been called to the technical excellence, or imperfections, of the pictures and the influence of the quality on the interpretation that can be made.

The attention given to the limitations on interpretation in case after case throughout this book leaves one at the end with the feeling that even the cloud chamber, which provides more detailed information about individual cosmic ray events than any other instrument (except perhaps the photographic emulsion), is still so severely limited that the pathway to further knowledge is very hard. For the student this emphasis on the limitations, as well as the powers, of the instrument is essential to provide a proper balance.

In many respects the virtues of the cloud chamber and the photographic emulsion in cosmic ray research are complementary, and both techniques share the virtue of pictorial clarity. In the field of publications, an obvious need is to supplement this fine collection of cloud chamber photographs of cosmic radiation with a similar book exhibiting photomicrographs of representative cosmic ray events observed in photographic plates. The summaries of the interpretations that might accompany such pictures would be of educational value equal to those in the present book and the duplication of subject matter would be so little that every teacher and researcher in high energy physics would want copies of both books on his desk.

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***High-Energy Particles.*** Bruno Rossi. New York: Prentice-Hall, 1952. 569 pp. Illus. $12.50.

"If the past is any guide, theory will probably continue to lag behind the observational approach," says a recent research review. Must the same be said of elementary particle physics? This subject engrosses the greatest concentration of talent in theoretical physics ever seen. All minds work to open the secret door, to reveal the glittering central mechanism, to comprehend in one view the stability of the half-dozen or so elementary particles (Table 1), and the processes which