SCIENTIFIC BOOKS

COSMIC RAYS

Cosmic Rays. By R. A. MILLIKAN. viii + 134 pp., 42 figs. New York: The Macmillan Company; Cambridge, England: The University Press. 1939.

THIS book grew out of three lectures, presumably of a popular nature, delivered in the University of Virginia in 1936, revised and delivered in Dublin in 1937, scientifically extended and published in 1939. Owing to the manner in which the book originated, it was not intended by Dr. Millikan that it should be regarded as a complete scientific text on cosmic rays. Yet it is an important human document, for it shows on the one hand Dr. Millikan in action as he states his views on social problems, and on the other as he presents the accumulation of evidence which may lead us to understand this mysterious cosmic phenomenon.

In the first chapter Dr. Millikan considers the value of science in human affairs. Necessity compels him to be brief. Had he wished he could have pointed out the amplification of the man power of a nation by the utilization of the energy of coal and water fall—an amplification of about 5,000 for the United States. He could have shown that modern industry, even modern warfare, is applied modern science. But he introduces this topic apparently to justify the idea that "the influence of great scientific discoveries . . . provides for the system of free enterprise." "Ideas are more potent than machines in determining the direction of human evolution and the fate of empires." He might have gone back to the year 1215 and the Magna Charta for support of this verdict, although in that case the influence of science was not impressive. Yet in this scientific age, and indeed in the enlightened land in which we live, Dr. Millikan finds some ideas not to his liking. These ideas are decidedly not due to cosmic phenomena, in fact, some of them flourish best in the progressive state of California. Many people there look upon the "ham and eggs" ideas as "sun kissed," but one infers that Dr. Millikan regards them as *moon-struck* or *ideas due to sunstroke.* (These terms are the reviewer's.) The author also seems to be under the impression that we can not acquire wealth by drowning a million pigs in the Mississippi. Though he does not say so, one infers that he would welcome a more scientific spirit in our government. "Scientists and engineers are always reactionaries—because they have learned by life-long experience that they can not improve bridge building and ignore the fundamental laws of structures which have already been discovered."

Having expressed himself vigorously regarding certain social or anti-social views, Dr. Millikan then deals with a few elementary physical topics—radiation, wavelengths, frequencies, photons, x-rays, radioactivity; he shows that the energies of particles or photons may be measured in terms of electron volts. The very early history of cosmic rays (up to 1922) is treated in one page. Then naturally and reasonably the work of Millikan and Bowen, Cameron, Neher, Anderson and Neddermeyer—the Pasadena School—fills nearly the rest of the book, but not to the exclusion of other important contributions.

The phenomena connected with cosmic rays are vast and exceedingly complex. The contributions to our knowledge of these phenomena made by the Pasadena workers are many and basic, but they are not the only ones. The discovery of the positron and, with substantial support from other workers, the discovery of the mesotron give to Anderson and Neddermeyer a premier place. The many beautiful cloud-track photographs in this book have been taken by Dr. Millikan's associates.

What are cosmic rays? The term implies that they are rays—particles or photons—which come to the earth from the vastly distant realms of space. But nearly all the phenomena which we see on the earth's surface and even for miles above the surface are due to secondaries originating in our atmosphere or secondaries raised to the nth power. The primary particles bombard matter, secondaries result. The process continues. Dr. Millikan does not always make it clear that he is presenting data in regard to secondaries. (The cloud-track photographs make it clear that this may be so.) Yet he is constantly striving to solve at once the riddle of the universe—what are the primaries, where and why do they originate? It would appear, in the light of experience since 1922, that it might be well to hold these questions in abeyance and to content ourselves with the more prosaic details of measuring the many characteristics of the so-called cosmic rays, ionization, penetration, curvature in a magnetic field, production of electron pairs, production of showers, intensity variation due to the earth's magnetic field (latitude effect), and due to altitude, variation due to atmospheric temperature (at all levels!). It was in this way that Clay discovered the latitude effect—a discovery that was discounted until Compton and his many associates completely affirmed his results. In this way Johnson and Street discovered that more particles come from the west than from the east, especially near the (magnetic) equator and at high altitudes (Johnson). These experiments prove that not only are electrified particles coming in the atmosphere but that there is a preponderance of positives. Dr. Millikan deals with all these details, although other writers might change the emphasis both with regard to the discovery and the discoverer.

The last two of the three chapters of the book are rather technical. Very especially is this so when Dr. Millikan discusses the Bethe-Heitler law of absorption

of photons and electrons, the energy regions in which it holds and does not hold. To follow the presentation along this line would lead us into a technical discussion.

The great contribution of the past three years in the realm of cosmic rays has been the discovery of the mesotron (meson, barytron, heavy electron). Of course we are shown the historic and unique photograph made by Neddermeyer and Anderson of the cloud track of a dying mesotron. But the very important photograph obtained by Street and Stevenson is not shown. In this photograph there are two tracks, one undoubtedly made by a proton, the other by the unknown particle. The curvature and ionization for each track are measured. A simple computation makes the mass of the unknown particle about 130 times that of an electron. Various observers have found ratios ranging from 100 to 800. Is there only one mesotron? What was it before it started on its brief (one millionth of a second) career of plunging with vast energy (200,000,000,000 electron volts?) through great thicknesses of matter? What does it become when it vanishes in thin air? This kind of question must in part be answered before we can hope to solve the riddle of the how, why and when of the origin of the primary cosmic rays.

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NON-UNIFORM GASES

The Mathematical Theory of Non-Uniform Gases. By S. CHAPMAN and T. G. COWLING. pp. xxiii + 404. Cambridge: University Press. New York: The Macmillan Company. $7.50.

THE scope of kinetic theory is defined by the authors as follows: "It is the province of a detailed kinetic theory to study the problems of non-equilibrium states, and such investigations occupy the greater part of this book. The probability methods of the kinetic theory are also, however, in the earlier chapters (3 and 4) applied to determine the equilibrium states; the results thus obtained are merely special cases of much more general results of statistical mechanics." The scope of this book is, however, further restricted to gases of medium density. Low densities, where collisions with the walls of the containing vessel are important, are not treated. An account of Enskog's work on dense gases is given in Chapter 16. In this work Enskog considered the collisions of smooth rigid elastic spherical molecules of finite size. Thus the space-filling property of molecules was taken into account, but not multiple collisions. These have not yet been considered in kinetic theory except by Wiener.[1] The scope is also limited to the mathematical theory. Thus the thermal diffusion coefficient is calculated and shown to be small, but experimental arrangements which multiply the effect of thermal diffusion so as to produce very good isotope separations are not discussed.

Within its scope the book is excellent. The fundamental equations of the subject were given by Maxwell and Boltzmann (1866 and 1872). They were first solved for the general case by Chapman and Enskog in 1916 and 1917 in papers often referred to but not often read. Chapman is senior author of this book, and the method used is that of Enskog, which is presented both clearly and rigorously for the first time. The distribution function is expanded in a convergent series, Sonine Polynomials forming an interesting part of the expansions. General formulae are thus obtained for the viscosity, thermal conduction, and diffusion coefficients. Special molecular models are considered. They are mostly spherically symmetrical force fields. When introduced in the general formulae they yield numerical results which are compared with experiments. Suitable choices of the fields are shown to give excellent agreement. The more direct atomic ray measurements of the force fields are not mentioned.

Ionized gases are considered in the last chapter, the effect of crossed electric and magnetic fields being studied quite thoroughly. Crossed concentration gradient and electric field, such as occurs when electrons are drawn through a slit into a gas, is, however, not treated.

The book is addressed to the theoretical physicist, as may be gathered from the 329 symbols listed at the beginning. To one interested in kinetic theory it should be essential.

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SOCIETIES AND MEETINGS

THE NORTH CAROLINA ACADEMY OF SCIENCE

THE thirty-ninth annual meeting of the North Carolina Academy of Science was held at Davidson College on May 3 and 4, 1940. Some two hundred members registered. About seventy papers were presented.

The executive committee reported one hundred new members elected since September; the University of North Carolina at Chapel Hill as the next meeting place; appropriation of funds to provide additional lantern slides for high-school loans; the treasurer's report (including delinquencies) to be submitted to the auditing committee before July 1st and published in the *Proceedings*.

The academy adopted the recommendations of the high-school science committee for its continued activity with high-school teachers, including the organization

[1] *Am. Jour. Math.*, 60: 897, 1938.