Books

A System of Symbolic Principles

The Nature of Physical Reality. A Philosophy of Modern Physics. By Henry Margenau. 479 pp. McGraw-Hill Book Company, New York, 1950. $6.50.

There has been during the last decades an increasing need for books on the philosophical foundations of physical science. Such a need was emerging in all periods of essential changes in the principles of science. This was the case in the period of Newton and is the case in our period in which the theory of relativity and the quantum theory brought about fundamental alterations in the structure of physics. There has been also a second root for this need. Everywhere, but particularly in the American universities, there has emerged a trend towards bridging the gap between the sciences and the humanities, towards "humanizing the sciences", particularly in connection with the sprucing projects for a "general education". There are very few good books of this kind because very few authors are actually competent in both physical science and philosophy. A man like Margenau, who is a prominent physicist and has given much thought and effort to the problems of philosophy, can render a great and welcomed service to the students of science and philosophy alike. Hence, the present book will provide a great stimulation and a great enrichment in their scientific outlook to students and, particularly, to instructors of science. The author achieves a good organization of his material by centering it around the problem of "physical reality". In chapter 1 he starts from "reality" as a common sense concept by a "preliminary survey of reality". In chapter 2 he describes some of the "ways of arriving at reality" which have been tried in the history of human thought. In chapter 3, "What is immediately given?", he investigates the realm of "sense data", the "completely passive component of experience", and shows that the concepts of traditional physics like position and velocity of particles do not belong to this realm of the "immediately given" and can, therefore, be interpreted in very different ways, if the advance of science requires it.

In chapter 4, "Departure from the Immediate", the author points out that the sense data themselves are not the building stones of physical science. The scientists proceed from them to "constructs" like "electromagnetic field strength", "mass", etc. The constructs are connected with the sense data by "rules of correspondence" according to which we relate, e.g., "electric field strength" to the pointer reading at a measuring instrument. Such constructs which turn out to be useful in science are called "verifacts". The luminiferous ether, e.g., is today a construct but not a verifact. In chapter 5 the author points out the important fact that constructs are not wholly determined by perception. If we examine the constructs which have actually formed the backbone of modern science, we find that they are also determined by what the author calls "metaphysical requirements", in addition to the requirement of being in agreement with our sense data. These six metaphysical requirements are: logical fertility, multiple connection, permanence and stability, extensibility of constructs, causality. In chapter 6 the method of empirical confirmation of constructs is treated. Chapter 7 is devoted to the special constructs "space and time" with a discussion of some recent views from Kant to Einstein. In chapter 8 the author discusses the old problem of whether science "explains" or merely "describes". Explanation is a description according to a certain pattern. The author characterizes this pattern as being based on the three constructs (or verifacts): "systems", "observables", and "states". Physical "systems" are masspoints, electromagnetic fields, etc. "Observables" are mass, energy, velocity, etc. A set of observables which is sufficient to describe a system and allows the prediction of the future is called a "state" of a system.

In chapters 9, 10, and 11 the author applies these general concepts to the main branches of "classical" physics: Newtonian mechanics, electromagnetic field theory, and thermodynamics.

In chapter 12 the author discusses "the role of definitions in science". He emphasizes the distinction between "epistemic definitions" of a construct which define the connection between this construct and sense observations and "constitutive definitions" which define construct by its relations to other constructs. In chapters 13 and 14 the author deals with "probability" and "statistics" and the place of these important "constructs" in physics. In chapter 15 the author gives a preliminary definition of "physical reality" by using the concepts introduced in the previous chapters. Roughly speaking, he terms "real" such "verifacts" which occur in "valid" physical theories. Such theories meet the "metaphysical requirements" and by using the "rules of correspondence" statements about sense observations can be derived that are in agreement with our experience. In chapter 16 the author shows how the "mechanical models" have lost their privilege of describing physical "reality". In chapters 17 and 18 the author applies his criteria of "reality" to modern quantum theory. These two chapters belong to the most interesting ones of the book.

Margenau formulated his criteria of reality from the start in such a way that they could be applied to quantum theory. He avoided in this way a treatment of quantum theory as something mysterious and irrational such as we meet in a great many papers and books about the philosophical implications of modern science. The author points out that the chief difference between traditional mechanics and quantum mechanics consists in the "rules of correspondence". In Newton's mechanics the value of an "observable" such as "position of a particle" corresponds to one small set of observations (e.g., the three coordinates). But in quantum mechanics a very great number of observations have to be made before we can compute, by averaging, the value of the "observable" which is called "position of a particle". These averages can be calculated by means of the Schroedinger wave function (psi function). A "state" of a system is defined by this Schroedinger function. According to Margenau, the psi function is an important piece of the "physical reality". Since by the Schroedinger equation the psi function can be computed for all future time, if it is given for the present instance, the "state of a system", defined in this way, obeys the law of causality and fulfills, therefore, a metaphysical criterion of reality. In chapter 19 the author elaborates this problem of causality more precisely and from different angles. Chapter 20 discusses Pauli's "exclusion principles" and in the closing chapter 21, "The contours of reality", the author gives a brief summary of what he regards as the "physical reality".

The book is written in a fluent and appealing language.

It will, certainly, be very helpful for instructors who have to teach the philosophy of science and will also be accessible to students who are strongly interested in physics from the philosophical angle. The reader needs a certain degree of knowledge in mathematical physics. If this is the case, he will find in chapter 17 a presentation of the quantum theory in an understandable way with an emphasis on the points which are relevant for philosophical analysis.

Among scientists and scientifically minded philosophers there is today a general agreement about the logical structure of science. The analysis of science which has been performed around 1900 by men like E. Mach and H. Poincaré and which has been refined and integrated by men like H. Schlick and the group of Logical Empiricism (sometimes called Logical Positivism) has become today the backbone of every presentation of the philosophy of science. Margenau's book follows essentially the same line. In refusing "simple realism" he accepts the basic tenets of logical positivism: science consists of (1) a system of relations between "constructs", (2) the rules of correspondence, and (3) the mathematical and empirical checking of this system. Margenau's analysis of science is hardly different from the standard presentation of Logical Positivism that is given in the monographs: *Foundations of Logic, Mathematics and Physics* (Encyclopedia of Unified Science). However, Margenau introduces some expressions which are borrowed from traditional "idealistic" and "realistic" philosophy. Although his analysis of science is actually in full agreement with the analysis given by logical empiricism, these terms are added in order to provide some of the psychological satisfaction which one gets from traditional philosophy. The two principal terms of this kind are "reality" and "metaphysics".

Actually Margenau rejects "realism" and, implicitly, "reality" as a metaphysical concept. He uses, as a matter of fact, the expression "physical reality" to denote a system of symbolic principles from which, by means of the "rules of logic" and the "rules of correspondence", the observed facts can be derived. The word "reality" is here a kind of honorary title which is given to the most useful and beautiful system of this kind. There is certainly nothing wrong in this way of speaking. But one has to be clearly aware that this presentation has nothing in common with the metaphysical conception of reality and is "strict positivism". In a similar way the "metaphysical requirements" which a system has to fulfill, according to Margenau, and which are formulated in chapter 5 (as we described above), are, exactly speaking, "pragmatical requirements". They formulate the conditions under which the system is practical and beautiful. Margenau emphasizes repeatedly that these requirements are not of eternal validity but are changing during the evolution of human thought. Margenau says very aptly that the characteristic of metaphysical requirements is merely the slower rate of change. But, then, the distinction between "pragmatical" and "metaphysical" requirements disappears completely. There is hardly any difference between this kind of metaphysics and the "antimetaphysical" positivism.

There is, however, some risk in the terminology which is used in this book if it is taken too seriously. Margenau makes, e.g., the point that in the realm of subatomic phenomena the psi function is a part of the physical reality but the particles are not. This way of speaking can evoke the illusion as if a statement about "what is real" were a statement about facts. Strictly speaking, such a statement is a definition. "Causality" belongs to the author's definition of "reality" and he concludes that the particles cannot be "real" because they do not follow a causal law; but the "psi function" is "real" because it is determined by a differential equation. All this amounts to accepting the definition that what is to be "real" is to be "causal". By a slight change in the definition of "reality" we can prove that the psi function is an ordinary construct and the particles are "real". This was actually done by W. H. Werkmeister in his books and papers on the philosophy of science. It seems to me that the shortcomings of this way of speaking about "reality" become conspicuous when one tries to present Bohr's theory of "complimentarity" in this language. Margenau says: "Bohr does not ask science to make a choice. . . . We believe that science, in all its applications of quantum mechanics, has in fact made its choice, and its choice was the second alternative (description of nature in terms of the psi function instead of the position of particles)." But Bohr wanted to say that no choice of this kind would be scientifically attainable. Any decision would be, therefore, scientifically speaking, meaningless. The two alternatives of this choice are descriptions of the same phenomena for different purposes. Therefore, descriptions by psi function and by particles each serve their purpose equally well.

Although the centering of the book around "physical reality" is certainly a great help for a tight organization of the material and for attracting the interest of the student, there is also a certain danger in bringing into the focus of attention a concept which is very debatable. It leads easily to blurring the boundary line between questions about facts and about definitions.

Philipp Frank
Harvard University

Books Received

THE EVOLUTION OF SCIENTIFIC THOUGHT: From Newton to Einstein (Second Edition). By A. d'Abro. 481 pp. Dover Publications, Inc., New York, 1950. $3.95.

STRUCTURAL CHEMISTRY OF INORGANIC COMPOUNDS. Vol. I. By Walter Hückel. 437 pp. Elsevier Publishing Co., Inc., New York, 1950. $9.00.

TRANSMISSION LINES AND NETWORKS. By Walter C. Johnson. 361 pp. McGraw-Hill Book Co., Inc., New York, 1950. $5.00.

ANNUAL REPORT—1949—CONFERENCE ON ELECTRICAL INSULATION. Division of Engineering and Industrial Research, National Research Council, Washington, D. C., 1950. 89 pp.

TABLE OF THE BESSEL FUNCTION $Y_0(z)$ AND $Y_1(z)$ FOR COMPLEX ARGUMENTS. Prepared by Computation Laboratory, National Bureau of Standards. 427 pp. Columbia University Press, New York, 1950. $7.50.

RADIO COMMUNICATION AT ULTRA HIGH FREQUENCY. By John Thompson. 203 pp. Methuen & Co., London, 1950. $4.50.

NUCLEAR DATA. National Bureau of Standards Circular 499. 309 pp. U. S. Government Printing Office, Washington 25, D. C. $4.25, Incl. supplements.

OUR NATURAL UNIVERSE—INCLUDING MAN. By Percy A. Campbell. 75 pp. College Offset Press, Philadelphia, Pa., 1950. $2.00.

PHOTOGRAPHIC OPTICS. By Allen R. Greenleaf. 214 pp. The Macmillan Co., New York, 1950. $4.75.

MOLECULAR SPECTRA AND MOLECULAR STRUCTURE. I. SPECTRA OF DIATOMIC MOLECULES (Second Edition). By Gerhard Herzberg. 658 pp. D. Van Nostrand Co., Inc., New York, 1950. $9.75.