Book Reviews

Copenhagen Interpretation

The Concept of the Positron. A philosophical analysis. Norwood Russell Hanson. Cambridge University Press, New York, March 1963. ix + 236 pp. $5.95.

There is no doubt that this is an outstanding book, both as philosophy and as history of science. It is somewhat misleading, however, to bill it as a book about the discovery of the positron. The fact is that the last chapter, although delightful reading, is almost entirely independent of the rest of the book. If Hanson had dropped the last chapter and titled the book "Philosophy of Quantum Mechanics," the real nature and importance of the book would have been clearer. Instead, such passages as "this has been a third long step towards the positron" have been put into each section of the book (quite untruthfully in my opinion), and the book nowhere mentions that many chapters have been previously published as journal articles.

This is unimportant, however. The fact remains that chapter 1, "Light," is brilliant history (how many people are aware that Newton believed in the *dual* nature of light—*both* waves and corpuscles—and on what grounds?) and genuinely relevant to the rest of the book, and that chapters 1 through 7 constitute the best sustained defense of the Copenhagen Interpretation of quantum mechanics in print. Chapter 8, "Equivalence," and the last chapter (chapter 9), on the positron, are related to the others through their common concern with quantum mechanics—thus the book might, I repeat, have been revealingly titled "Philosophy (and Some History) of Quantum Mechanics."

According to the Copenhagen Interpretation, a particle whose position is unmeasured has *no* "sharp" (numerical) position *at all* (compare chapter 7, "Uncertainty again"). Experiments have shown self-interference effects, in the case of the photon, at 20-foot separations. If we accept the Copenhagen Interpretation, we have to conceive of macro-objects (like tables and chairs) as somehow retaining "sharp" positions and outlines, although they consist of particles whose positions can be "unsharp," even by macroscopic standards. The charge against the Copenhagen Interpretation is that it provides no satisfactory explanation of this fact.

The "classical limit" theorems do explain it in some cases, but not in the perfectly possible case of a macro-object whose position is partly determined by the outcome of a quantum mechanically uncertain event (as in the famous "Schrödinger's Cat" *Gedankenexperiment*). Some of the proposed "solutions" to the difficulty are: *to say the observer throws the object observed into a sharp state* (von Neumann); or to say the macroscopic detector does this (Bohr). Of course, this last *assumes* just what is to be *explained.*

Hanson has two lines of argument:

1) He suggests that macro-objects fall outside the province of quantum mechanics anyway, and there is thus no problem. This seems untenable. It is true that we cannot determine the state function of, say, a rocking chair (just as we could not *really* have determined the position and momentum of each particle of the rocking chair *exactly*, even if classical physics had been true); but we can describe our knowledge of its state by a statistical mixture. Thus classical objects fall into the range of quantum mechanics just as surely as they fall into the range of classical particle mechanics. Hanson does Mehlberg an injustice by suggesting that Mehlberg was unaware of the fact that classical mechanics is not *literally* deducible from quantum mechanics, even for macro-objects (if it were, there would be no problem!); but Mehlberg was challenging the quantum mechanist to explain macroscopic *objects*, not classical macroscopic *theory*. This confusion runs throughout Hanson's book.

2) Hanson suggests that the wave function of an electron is really just a predictor of the electron's probable effects on macroscopic detectors. But in what language are these effects to be described? In the terminology of classical mechanics? That is, are they to be described in the terminology of an inadequate theory? Or are they to be described in terms of wave functions (which would then be probabilities of probabilities of probabilities of . . .)?

I have already said that this book is the best defense of the Copenhagen Interpretation I know of. Unfortunately, even the best defense does not make that interpretation seem both intelligible and plausible.

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A Geometric Approach

Elements of Linear Spaces. A. R. Amir-Moez and A. L. Fass. Pergamon, New York, 1962. ix + 149 pp. Illus. $5.50.

That many textbooks of linear algebra have been published in recent years is not surprising, since there is hardly a science—physical, biological, or social—which does not now need the techniques of this subject. It is surprising, however, that few introductory texts have attempted a consistent development of the ideas of the subject through the use of two- and three-dimensional euclidean geometry. Of course, little bits and pieces of elementary geometry appear in examples, but in most texts algebraic ideas are not developed first in a geometric setting.

The authors claim to have attempted such a geometric approach to linear algebra in this book. In the first five chapters two- and three-dimensional real euclidean spaces are treated as linear spaces, and the general ideas of linear dependence, inner product, linear transformation, and the like are introduced within this concrete geometric framework. In the second edition the ideas treated in these first chapters are extended to n-dimensional vector spaces over the complex numbers. Finally, there is a brief treatment of abstract vector spaces over any field and of linear transformations of such spaces in addition to a discussion (also brief) of general inner products and unitary spaces.

The book is not bad, but neither is it good. The authors frequently indulge in sloppy and careless mathematics reminiscent of old-fashioned geometry texts used at the college level—for example: the incomplete definitions and proofs in the early pages, mainly caused by a careless disregard for the zero vector; the frequently used technique of defining some object as *the* such and such, when the definition by no means makes it clear that there is only one such object or that there is anything at all which satisfies the condition.

A good case may be made for the idea of approaching linear algebra through elementary geometry and also for teaching linear algebra as the student's first introduction to modern algebra. But, whatever the approach, the treatment must be in the spirit of modern algebra; unfortunately such is not the case in this book.

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A Real Physicist

The Collected Papers of Enrico Fermi. vol. 1. Italy, 1921–1938. Emilo Segrè, Ed. University of Chicago Press, Chicago, Ill., 1962. xlii + 1043 pp. Illus. Plates. $15.

Volume 1 of *The Collected Works of Enrico Fermi* includes all of his papers published before Fermi left Italy and came to the United States. In a sense the papers are an epitome of one of the most brilliant periods in the history of physics, a period of which Fermi was one of the great luminaries. The vast range of subjects covered, both theoretical and experimental, including as it does quantum mechanics, relativity, quantum electrodynamics, and atomic structure, as well as the beautiful experiments in optics and his basic discoveries in neutron physics, is almost incredible. Fermi was one of those rare individuals, a real physicist without the qualifying adjective experimental or theoretical. Such individuals are always rare, and in these days of increasing complexity in physics, whether it be experimental or theoretical, a star of such magnitude, a real Renaissance figure, cannot be replaced.

One of the most valuable features of this collection is the introductory biography of Fermi written by Emilio Segrè, one of his most distinguished students. We have here no ordinary recital of achievements and publications, but rather a careful analysis and assessment of the tremendous importance of Fermi in the history of modern physics. This short biography, together with Laura Fermi's charming volume *Atoms in the Family*, gives a fair understanding, for a first appraisal, of Enrico Fermi and of his personality as scientist, colleague, student, and family man. When other papers, which will include Fermi's great work on chain reactions and high-energy physics, are published, his vast powers will again become manifest. This volume treats what I consider, from a scientific and a humanistic point of view, the more important phase of his very rich life.

Of course these collected papers can not be described in a book review. It is to be hoped that this volume will make these great contributions accessible to interested students of physics and of science in general as well as to historians of science. Almost any paper picked at random is an important contribution to the structure of physics, and the papers are written in a style which is concise, charming, and compelling. To any one who will give himself to the subject, this is not a dry collection of minutiae, but a prime example of the great vitality and surge of the physics of the 1920's and the 1930's.

It is to be hoped that, with the increasing interest in the history of science, a devoted biographer of Enrico Fermi will be found, one who will give us a full-length biography which will explore Fermi's scientific publications and his philosophical and political orientation and also trace the development of the interests and tastes of this extraordinary genius. By this time a personality of such magnitude in the humanities would have been the subject of studies by a number of students. In this so-called age of science a similar effort should be made to obtain a more profound understanding of scientists' personalities and of their contributions, for scientists represent the principal driving force of our age.

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Nonmathematical Statistics

Statistics. George H. Weinberg and John A. Schumaker. Wadsworth, Belmont, Calif., 1962. xii + 338 pp. Illus.

This book is intended for use in a first course on statistics for students in such fields as psychology, education, social science, whose only mathematical skill is the ability to substitute into algebraic expressions. About one-third of the book is devoted to descriptive statistics. The remainder introduces the most widely used simple tools of statistical inference.

The primary strength of the book is the evident pedagogical care with which it has been written. Apparently the authors have seen many confused students trip over certain points, and they have tried to smooth the way. This can be moderately amusing when, for example, five paragraphs and two figures are devoted to showing that $(\Sigma x)^2$ and $(\Sigma x)^2$ are *not* equal. But there are many students for whom this investment in ink is justified. Most nonmathematical beginning students may benefit from the authors' frequent practice of first illustrating by example an important mathematical proposition and then stating the theorem that the example makes plausible.

The book's weaknesses fit its strengths. It is highly redundant. In making ideas easy, it occasionally introduces serious conceptual fuzziness. For example, it is inadequate to define a random sample of size N as one where every individual is as likely to be drawn as every other; it is necessary that every *sample* of size N be equally likely. Again, I wish that the discussion of one-tailed versus two-tailed tests was more incisive.

There are a few errors which should be corrected. The definition of unbiasedness is simply incorrect; the defined property is actually consistency. Figures 16.3, 16.4, 16.5, 16.8, 16.9, and 16.10 show regression lines which fit the data so badly that they confuse rather than inform the reader. The student should not be told (p. 271) that linear regressions are to be fit in preference to curvilinear ones because they are easier to extrapolate!

The book should be useful in courses intended largely to present descriptive statistics to students for whom an easy book is very important.

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