Book Reviews

Radiation Theory Between 1896 and 1925

The Tiger and the Shark. Empirical Roots of Wave-Particle Dualism. BRUCE R. WHEATON. Cambridge University Press, New York, 1983. xxiv, 355 pp., illus. $39.50.

Bruce Wheaton describes his book as "the story of a radical change in man's concept of light." In 1896, when his story begins, physicists were convinced that light consists of electromagnetic waves, a conviction based on evidence accumulated over the course of the 19th century. During the next few decades that belief about the nature of light was put in doubt, along with so many other beliefs that had seemed indisputable in the 1890's, and physicists had to learn to live with a growing uncertainty about the adequacy of the wave theory of light. Electromagnetic radiation behaved in puzzling ways in a variety of experimental situations, showing "properties no wave has any business to have," as H. G. J. Moseley wrote in a passage quoted in this book. By the mid-1920's, when Wheaton ends his story, Arthur Compton's great discovery had "sounded the death knell" of the wave theory, in Arnold Sommerfeld's words, and physicists were prepared to accept far-reaching changes in the very basis of their science. These changes were expressed in the new quantum mechanics, which incorporated the wave-particle duality for radiation and for matter as well.

The first theoretical arguments that cast doubt on the wave theory and suggested particle-like behavior for radiation were put forward by Albert Einstein in 1905. A few years later he was pointing to the need for a new fundamental theory of radiation that would include both its wave and its particle aspects. Einstein's arguments fell on deaf ears for a long time. One of Wheaton's principal points is that other physicists, many of them unaffected by Einstein's arguments or even rejecting his proposal of light quanta, came to appreciate the need for a new approach to radiation on the basis of the paradoxical results of their own experiments, results that no wave theory could encompass. Two whose contributions Wheaton emphasizes were William Henry Bragg, father of Lawrence Bragg, and Maurice de Broglie, elder brother of Louis de Broglie.

Wheaton's story is no simple linear development; what history of human events ever is? It involves the complex interweaving of a number of strands, starting with the experiments initiated by Wilhelm Roentgen's discovery of his mysterious penetrating rays. Once these x-rays and the gamma rays, discovered in 1900 by Paul Villard in his experiments on radium, were identified as electromagnetic radiation, the evidence provided by their behavior had to be considered along with the results obtained with ordinary light. It was not easy to disentangle the sometimes contradictory conclusions drawn from absorption experiments, ionization studies, scattering studies, and investigations of secondary electrons (including the photoelectric effect). Wheaton has gone through an extensive literature, as indicated by his 35-page bibliography. In his discussion the reader will encounter such rare birds, now largely extinct, as the impulse theory of x-rays, the triggering hypothesis for the photoelectric effect, and W. H. Bragg's neutral pair interpretation of x-rays. Wheaton stresses two paradoxes, recognized very early by J. J. Thomson and Bragg, respectively, and forcefully restated in 1922 by Maurice de Broglie on the basis of much more solid and extensive experimental evidence: Why should the spherical wave or pulse that presumably constitutes an x-ray ionize only a very small fraction of the atoms over which it passes? Why should the energy of the electron set free in this ionization process be so much greater than the radiant energy in the small portion of the x-ray wave that it intercepts, be comparable in fact to the energy of the electron whose deceleration produced the x-ray in the first place?

Most of Wheaton's book is devoted to the period up to 1922. He emphasizes the experimental development, in welcome contrast to much writing about the history of science, but he also comments appropriately on the contributions made by theorists. His readers may be surprised to learn that the role of the early quantum theory in interpreting these experiments was less significant and less direct than textbook accounts would suggest. Wheaton argues effectively that the very success of the Bohr-Sommerfeld quantum theory of atomic structure and spectra helped to divert the attention of theorists away from the problems of radiation for a number of years. He also presents an interesting argument for the close connection between the experimental tradition described in his book and Louis de Broglie's proposal of matter waves. Louis de Broglie's discussions and collaboration with his older brother Maurice were an influence comparable in importance to his study of Einstein's papers.

One might have expected this account of the "empirical roots of wave-particle dualism" to give a significant place to Compton's work, but Wheaton has surprisingly little to say about it, devoting a mere three pages to the "so-called Compton effect." He assigns much less importance to Compton's results and their theoretical interpretation than has any previous writer on this subject. Wheaton describes Compton's explanation of his results by the use of the light quantum as part of a "reawakening of interest" in the quantum in the early 1920's. I must disagree with Wheaton's evaluation here. The reawakened interest in the light quantum was largely negative, and those who discussed it in 1922 were still rejecting Einstein's ideas. Compton's work did make a crucial difference. Wheaton also seems to ignore the detailed analysis of the development of Compton's thinking given by Roger Stuewer in his book *The Compton Effect* (1975), a book Wheaton refers to only in a rather cavalier way.

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Wallace and Darwinism

Just Before the Origin. Alfred Russel Wallace's Theory of Evolution. JOHN LANGDON BROOKS. Columbia University Press, New York, 1984. xvi, 284 pp., illus. $30.

John Langdon Brooks believes that Alfred Russel Wallace has not received sufficient attention from historians of evolution theory. This book surveys Wallace's career to 1858, when his paper on natural selection prompted the joint Darwin-Wallace publications on the theory and forced Darwin to begin writing the *Origin of Species*. Wallace spent the