reviews

Waves or particles?

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A. H. Compton at work

THE discovery of X rays by Röntgen in 1895 gave rise to considerable speculation as to whether this radiation was corpuscular, like electrons, or undulatory, like light. As the experimental evidence grew so it became apparent that, like light, X rays must be a form of electromagnetic radiation; Barkla demonstrated that X rays could be polarised and in accordance with J. J. Thomson's theory, this was taken as clear evidence for their being electromagnetic waves; this conclusion was reinforced some years later by Friedrich, Knipping and Laue, who showed that they could be diffracted. Nevertheless there was one property of light which eluded a satisfactory explanation on this wave basis and that was the photoelectric effect. The only simple explanation for this phenomenon was given in 1905 by Einstein, who published his well-known paper on the light quantum interpretation of the photoelectric effect and derived his famous relation $eV=h\nu$. Not much notice was taken of Einstein's contribution and the view was firmly held by the majority of physicists that light and X rays were electromagnetic waves and this therefore excluded them from possessing particle properties. Even as late as 1916 Millikan, in the paper reporting his experiments on the photoelectric effect which exactly confirmed the Einstein relation, commented: "Yet the semicorpuscular theory by which Einstein arrived at his equation seems at present to be wholly untenable". This relationship was accepted as convenient and reliable and it was presumed that it would ultimately prove explicable on electromagnetic theory.

It was at this stage that A. H. Compton came on to the scene. He had started his research under O. W. Richardson at Princeton in 1914 on X-ray diffraction and, after some abortive experiments to look for magnetic scattering of X rays, commenced his experiments on the spectrum of the scattered radiation. These were absorption experiments and they showed that, together with the radiation of unaltered wavelength, there also seemed to be softer radiation present. Barkla had observed this radiation and interpreted it as fluorescent radiation characteristic of the scatterer—but longer in wavelength than those lines which can be understood by the Bohr model—and named it J radiation. Compton, adhering strongly to electromagnetic theory, chose to interpret the changed adsorption coefficient not as a change in wavelength, but as being due to the size and shape of the electron: by assuming that it was a rather large object and of ring shape, he found that he could account for the reduced absorption coefficient in the conditions of his experiment. After visiting Cambridge in 1919, where Rutherford viewed his large electron with some scepticism, he returned to the US and attacked the scattering problem again, this time using a Bragg spectrometer as a monochromator of the incident X rays. He then found an explanation for the softening of the X rays in terms of Doppler displacement of the radiation from the moving electron, which had received momentum from the incident X rays. He was still, however, unable to account satisfactorily for all the features of scattering and it was only at this stage in October 1922 that he found that a corpuscular interpretation would account fully for all his observations. Quite quickly, most physicists accepted this interpretation of his convincing experiments and thus accepted the particle nature of electromagnetic radiation. Thus, some 17 years after Einstein's original paper on the photoelectric effect, the scientific community recognised the fact that light and X rays each possessed both wave and particle characteristics.

In this book* Dr Stuewer, an historian of science, traces the ideas and background to Compton's experiments which were to prove important in the development of wave-mechanics. The author, using material drawn from published papers and letters, guides the reader through much of the history of the particle–wave duality. It is liberally referenced and sprinkled with detailed theoretical arguments, and the tenacity with which physicists held to the classical electromagnetic theory emerges very clearly in this book. This piece of physics history will be primarily of interest to physics graduates and, although lacking the gossipy and humorous touches of biography, it nevertheless provides a vivid, enjoyable and definitive account of one of the crucial steps in the establishment of quantum mechanics. It is an unusual work and should have a place in the library of the physicist who is interested in more than the bare bones of his subject.

M. A. Grace

**The Compton Effect: Turning point in Physics.* By Roger H. Stuewer. Pp. xii+367. (Science History: New York, April 1975.) n.p.