The downfall of determinism

The Tiger and the Shark: Empirical Roots of Wave-Particle Dualism

Bruce R. Wheaton
355 pp. Cambridge U.P., 1983
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Reviewed by Pierre Noyes

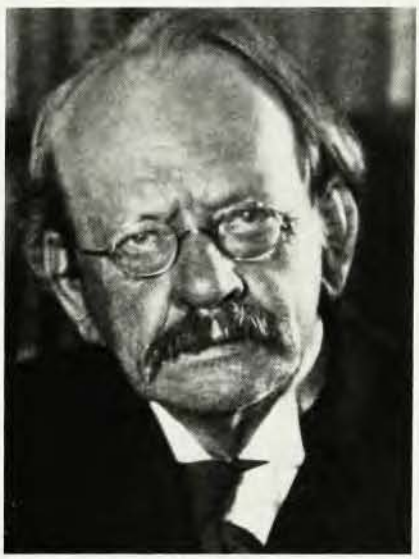
J. J. Thomson in his *Structure of Light* (Cambridge U.P., 1925) compared the interplay between wave and particle theories of radiation to "a struggle between a tiger and a shark, each is supreme in his own element, but helpless in that of the other." The struggle between wave and particle theories described in this book does not identify which is the tiger and which the shark. The author shows us something of the bloody beach suggested by the analogy, but more of the often neglected history of the empirical study of x and γ rays. Theoretical and experimental physicists, teachers of physics, and philosophers of science would be well advised to learn from this history rather than to have to relive it.

The foundations of quantum physics were laid between 1896 and 1925—the period covered by this book. Most practicing physicists have learned what little they known of the history of this period by reading textbooks written after the quantum revolution. Often texts or teachers treat the Planck radiation law, the Einstein photoelectric equation, the Bohr atom and the Compton effect in one sequence assuming that this provides an adequate background for understanding $E = h\nu$ and $p = h\nu/c$. This can leave a student with less than total respect for the physicists who took so long see the "obvious" necessity for this form of quantization. Bruce Wheaton's historical study removes much of the mystery; we also learn that physics can be "national" and that hard work is needed to achieve consensus.

The British tradition of mechanical models created pressure to look for the explanation of x rays—if they were to be fitted into Maxwell's theory, rather than studied as particles—as either the missing longitudinal component of an "elastic solid," or transverse "pulses" with no assignable frequency, but an assigned intensity and duration. The continental approach was more abstract, using Fourier analysis to make sharp pulses without trying to envisage a physical mechanism. In Bruce Wheaton's words, "The gradual recognition . . . that internal consistency is unattainable by electromagnetic interpretations is the subject of this book."

The study of x rays focused early on two problems which Wheaton calls *the paradox of quantity*: an x ray beam ionizes only some of the atoms over which it passes, and *the paradox of quality*: the high velocities of the secondary electrons produced by ionization. Both make sense if x rays are considered particles, but not if they are viewed as spherically spreading electromagnetic pulses. It is as if one dropped a log into a pond, and subsequently at some distance a similar log suddenly jumped up to the same height. The paradox was deepened once the interference of x rays was established, and the paradox was extended to visible radiation. Yet Einstein's light quantum hypothesis and theory of the photoelectric effect continued to be dismissed as radical speculation. The two paradoxes were forcefully raised once more by the careful experimental work of Maurice de Broglie and remarks in his 1922 book on the physics of x rays. Maurice de Broglie "may have been the loudest voice in Louis de Broglie's ear, but his was not the only voice." As the book shows, "The insight of Louis de Broglie that led to the most complete formulation of wave-particle dualism was the last act in a series of preliminary attempts."

The complicated interplay between theory and experiment as presented in this book deserves careful study. The resolution of these difficulties by the abandonment of determinism was then considered a high price to pay. And for some that price is still too high. The recent experimental work on Einstein-Podolsky-Rosen distant correlations attests the lengths to which some physicists will still go to convince themselves that the price *has* to be paid. Thus attention to this early work is clearly of contemporary, and not just historical or pedagogic, interest. The author is to be warmly commended for performing this task in such a clear and useful fashion.



Louis de Broglie and Joseph John Thomson, two central figures in the controversy over the nature of x rays.

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