Abraham, Max | Encyclopedia.com

(*b*. Danzig, Germany, 26 March 1875; *d*. Munich, Germany, 16 November 1922)

physics.

Abraham was born to a wealthy Jewish merchant family. He studied under Max Planck and completed his doctoral dissertation in 1897. He than assisted Planck at Berlin and in 1900 assumed the position of *Privadozent* at Göttingen.

Abraham's lifework amounted to the explication of Maxwell's theory. He exhibited a virtuosity in the handling of Maxwell's equations like few others before him. In spite of his many original contributions, however, he was repeatedly passed over for academic appointments. This was due to the fact that he had no patience with what he considered to be silly or illogical argumentation. Abraham had a penchant for being critical and had no hesitation in publicly chastising his colleagues, regardless of their rank or position. His sharp wit was matched by an equally sharp tongue, and as a result he remained a *Privatdozent* at Göttingen for nine years. In 1909, he accepted a professorship at the University of Illinois, but he did not like the atmosphere at a small American university and returned to Göttingen after one semester. He then took the post of professor of rational mechanics at the University of Milan, where he remained until 1914. When World War I broke out, he was forced to return to Germany. He spent the war years investigating theoretical problems in radio transmission for the Telefunkengesellschaft. After the war, unable to return to Milan, he subsituted as professor of physics at the Technische Hochschule at Stuttgart. Finally, in 1921, he was stricken with a fatal brain tumor. Abraham died after six painful months in a hospital in Munich. "Just as his life was suffering, his end was full of agony" (Born and von Laue).

Abraham is best remembered for his two-volume textbook, *Theorie der Elektrizität*, which went through five editions during his lifetime. Volume I, first published in 1904, was an adaptation of Föppl's *Einfuhrung in die Maxwellsche Theorie der Elektrizität*. Volume II, subtitled "Der Elektromagnetische Theorie der Strahlung" ("The Electromagnetic Theory of Radiation") contained Abraham's theory of electrons. It appeared in 1905. Subsequent to Abraham's death the book was revised under the authorship of Abraham and Becker. Today the modern counterpart of Abraham's text, R. Becker and F. Sauter's *Electromagnetic Fields and Interactions*, is in use.

The Abraham textbook was the standard work in electrodynamics in Germany for several generations of physicists. His consistent use of vectors was a significant factor in the rapid acceptance of vector notation in Germany. But one of the most noteworthy features of the text was that in each new edition Abraham saw fit to include not only the latest experimental work but also the latest in theoretical contributions, even if these contributions were in dispute. Furthermore, he had no hesitation, after explicating both sides of a question, in using the book to argue his own point of view. This was especially true with regard to theories of the electron as well as with regard to rival views of space and time.

Abraham's theory of the electron was developed in 1902 shortly after a close friend. Wilhelm Kaufmann, had published his first tentative experimental results on the variation of the transverse mass of the electron as a function of its velocity. The basic underlying assumptions of Abraham's theory were, first, that the conception of an ether in which electromagnetic phenomena took place was valid and, second, that the differential equations of the electromagnetic field (Maxwell's equations) are applicable to the dynamics of electrons. In Abraham's view, the central question that had to be answered before any other was to what extent the mass of the electron was electromagnetic. If all mass of the electron could be ascribed to the interaction of the electron's charge with electromagnetic fields, then one could hope to build a consistent and universal physics based on electrodynamics. Abraham's approach was to calculate the inertia due to the self-induction of the electron as it moved through its own field and the induction due to any external field in which the electron found itself. One could compare the results thus obtained with Kaufmann's results, and if agreement was substantial, then it could be said with some assurance that the mass of the electron was purely electromagnetic. The analysis was difficult, sophisticated, and lengthy. However, making the assumption that the electron was a perfectly rigid sphere and that the charge is distributed uniformly on the surface of the sphere, Abraham calculated the transverse electromagnetic mass of the moving electron to be

where m_0 is the electron's rest mass and $\beta = v/c$, the ratio of the velocity of the electron to the velocity, of light. Expressed in terms of powers of β this equation becomes

Nothing that the data were very difficult to obtain, and that there was a high degree of uncertainty in Kaufmann's results, Abraham was pleased to find agreement between his own predictions and Kaufmann's data.

In 1904 H. A. Lorentz published his second-order theory of the electrodynamics of moving bodies. His expression for the mass of the moving electron, based on the conception of a deformable sphere which contracted in the direction of motion was which when expressed in terms of powers of β becomes

Of course, Einstein obtained the same result as a kinematic consequence of his special theory of relativity.

Finally, in 1906. Kaufmann undertook a new set of measurements in the hopes of distinguishing between Abraham's theory and those of Lorentz and Einstein. He reported that his experiments supported the Abraham theory. Although Kaufmann's work was later criticized on methodological grounds and later experiments vindicated the Lorentz and Einstein predictions, opponents of the theory of relativity often cited Abraham's theory and Kaufmann's data as evidence against Einstein's special theory.

Abraham himself remained unalterably opposed to Einstein's theory throughout his life. Early (ca. 1906–1910) he not only was convinced that the data did not support the theory, but he was unwilling to accept the postulates of the theory. By 1912 Abraham admitted that he had no objection to the logic of Einstein's theory: however, he expressed the hope that astronomical observations would contradict it, paving the way for the resurrection of the old absolute ether. "He loved his absolute ether, his field equations, his rigid electron just as a youth loves his first flame, whose memory no later experience can extinguish" (Born and von Laue). But throughout, Abraham's objections were not based on misunderstanding of the theory of relativity. He understood it better than most of his contemporaries. He was simply unwilling to accept postulates he considered contrary to his classical common sense.

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