Thomson's Two Experimental Papers

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XL. *Cathode Rays. By* J. J. THOMSON, *M.A., F.R.S., Cavendish Professor of Experimental Physics, Cambridge**.

THE experiments† discussed in this paper were undertaken in the hope of gaining some information as to the nature of the Cathode Rays. The most diverse opinions are held as to these rays; according to the almost unanimous opinion of German physicists they are due to some process in the æther to which—inasmuch as in a uniform magnetic field their course is circular and not rectilinear—no phenomenon hitherto observed is analogous: another view of these rays is that, so far from being wholly ætherial, they are in fact wholly material, and that they mark the paths of particles of matter charged with negative electricity. It would seem at first sight that it ought not to be difficult to discriminate between views so different, yet experience shows that this is not the case, as amongst the physicists who have most deeply studied the subject can be found supporters of either theory.

The electrified-particle theory has for purposes of research a great advantage over the ætherial theory, since it is definite and its consequences can be predicted; with the ætherial theory it is impossible to predict what will happen under any given circumstances, as on this theory we are dealing with hitherto

* Communicated by the Author.

† Some of these experiments have already been described in a paper read before the Cambridge Philosophical Society (Proceedings, vol. ix. 1897), and in a Friday Evening Discourse at the Royal Institution ('Electrician,' May 21, 1897).

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WHEN J. J. THOMSON began his research on the cathode rays during the 1890s, there was great confusion about their exact nature. As he noted in the introduction to his paper, "On Cathode Rays," [*Phil. Mag.*, Ser. 5, Vol. 44, No. 269 (1897), p. 293]:

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Following the lead of French physicist Jean Perrin, Thomson first satisfied himself that the rays were negatively charged, then addressed a quandary that had been puzzling scientists on both sides of the Channel for years. Although the rays were easily deflected by a magnetic field, they were apparently *not* deflected by an electric field between two plates. The absence of this deflection, he showed, was due to the ionization of the gas remaining in a cathode-ray tube, which permitted a current to flow between the plates and drastically reduced the field. This did not occur at high vacuum, however, and the rays were indeed deflected as expected for negatively charged particles. Thus he noted:

> I can see no escape from the conclusion that they are charges of negative electricity carried by particles of matter. The question next arises, What are these particles? [A]re they atoms, or molecules, or matter in a still finer state of subdivision?

By simultaneously deflecting the rays in *both* electric and magnetic fields, Thomson was able to determine their velocity and the ratio m/e of the mass m to the electric charge e carried by these (then) hypothetical particles. His result was startling:

> From these determinations we see that the value of m/e is independent of the nature of the gas, and that its value 10^{-7} [gram per emu] is very small compared with the value 10^{-4}, which is the smallest value of this quantity previously known, and which is the value for the hydrogen ion in electrolysis.

But he could not conclude from these data that m itself therefore had to be very small. "The smallness of m/e may be due to the smallness of m or the largeness of e," Thomson wrote. Because the values of m/e were independent of the nature and pressure of the gas, he began