

J.P.V. Madsen Experimental Techniques on Alpha, Gamma & Beta in 1907-1909.

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Introduction.

In the period 1906-1908 J P V Madsen conducted experiments on alpha, gamma and beta emanations from radium and uranium at Adelaide University with the involvement of Professor W H Bragg.

It is useful to consider the experimental techniques Madsen used consistently in sequence as reported in three papers (Alpha, Gamma & Beta) published in 1908 and 1909 leading to the significant conclusion that a beta particle is scattered only once in passing through very thin foils- this in turn contributed to the proposal of the nuclear atom in 1911, by both Madsen in January and Rutherford in March.

A notable feature of these three experiments is the use of gauzes, radiators and foils made of materials of different atomic weight and of different thickness of about ten iterations of each (ionised gas passed through gauzes, gamma radiation impinged on radiators causing secondary radiation and foils caused the scattering of beta particles.)

It would appear that the techniques used by Madsen were common at this time of early investigation into radio-activity led by Ernest Rutherford.

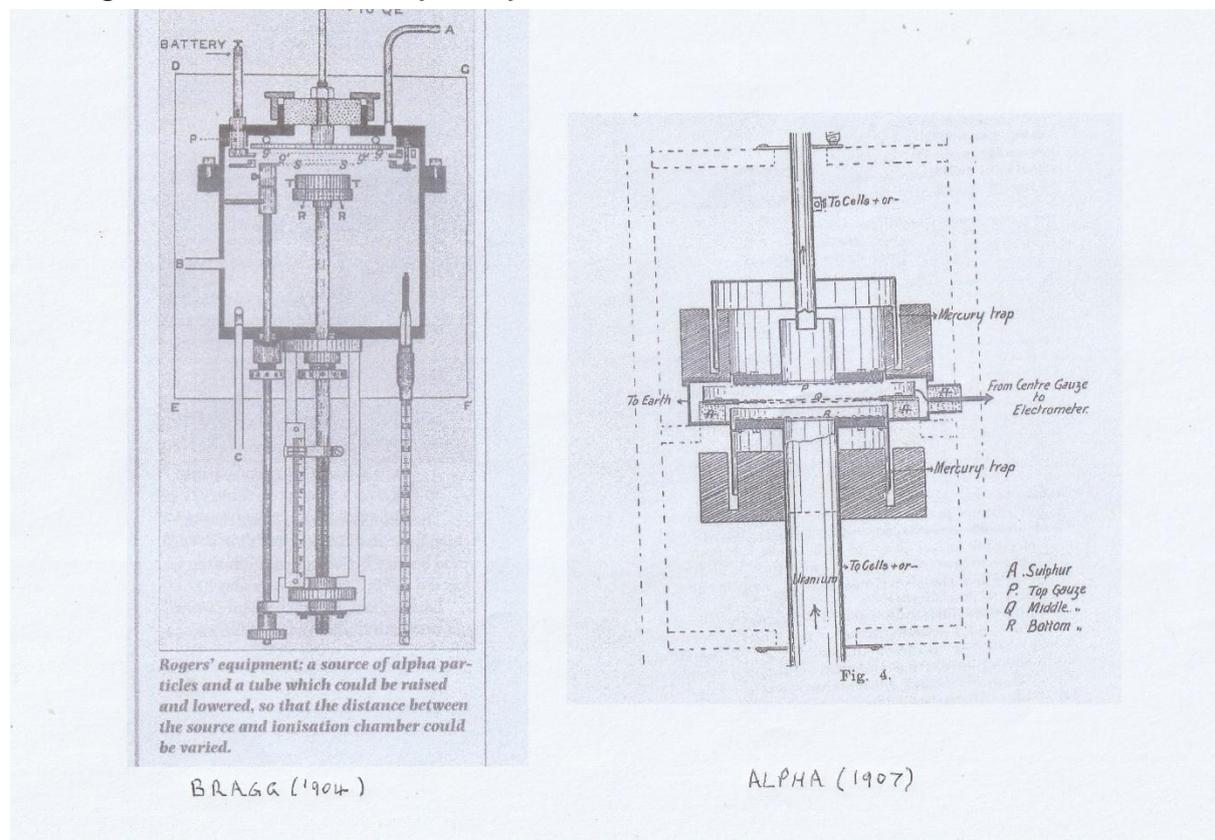


Plate 1 -Bragg (1904) shows the apparatus used by Bragg and Kleeman in 1904 to measure the distance from the Radium source of the 4 different energy levels found for

alpha particles. The Alpha (1907) apparatus used by Madsen taken from his DSc thesis, to investigate the recombination of ions when the uranium influence is removed.

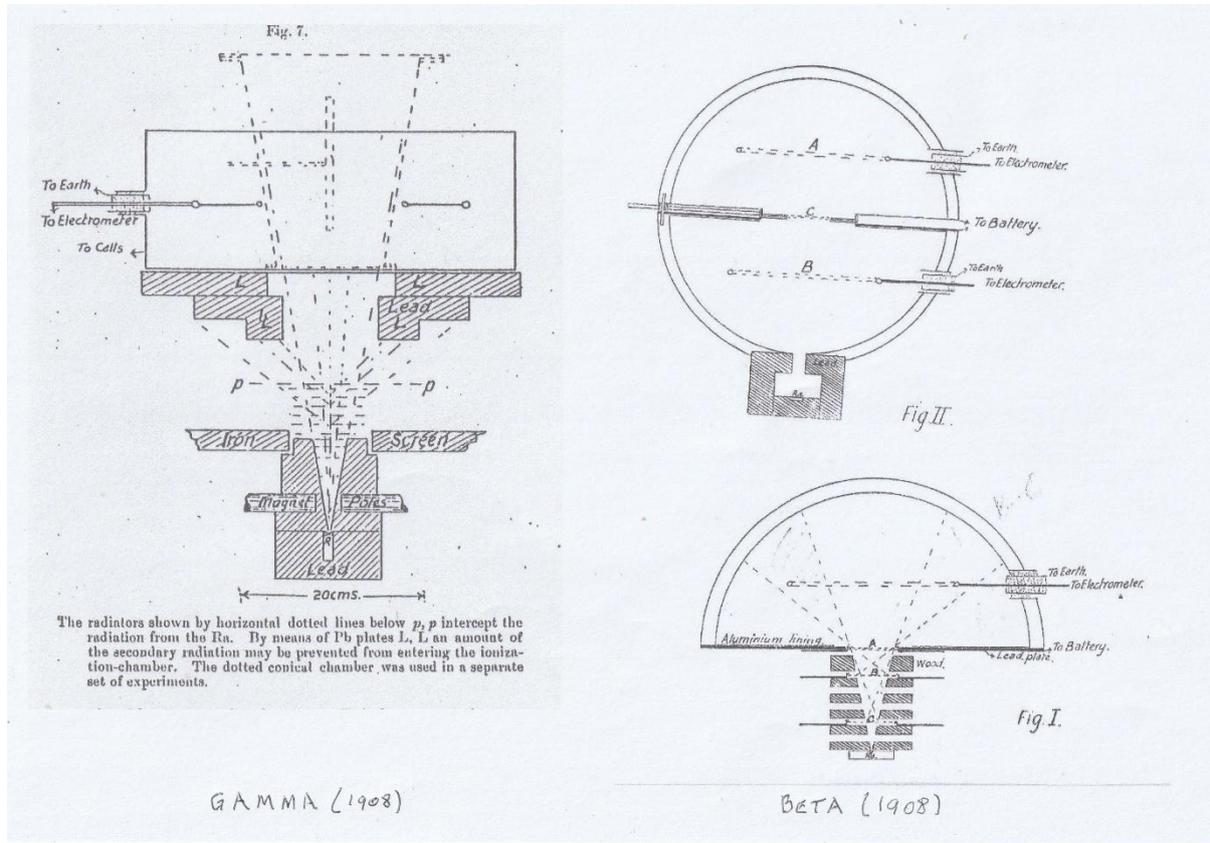


Plate 2- Gamma experiment by Madsen in 1908 to investigate secondary gamma radiation from radiators. Beta (1908) experiment by Madsen on the scattering of beta particles by thin foils.

Various techniques used by Madsen in the Alpha, Gamma and Beta experiments.

Source of Uranium and Radium: W H Bragg had obtained radium bromide and uranium oxide from Austria and it was put to very good use with R. Kleeman using the Rogers built ionisation apparatus in 1904. JPVM principally used radium bromide but for the Alpha work he did use both.

Electrometers: For the tiny ionisation currents Thompson Quadrant (75 divisions/volt) and Dolazalek (4,000 divisions/volt easily divisible into 10ths) electrometers were used.

Balanced Chambers: Because of large initial effects balanced chambers were used in Alpha, Gamma and Beta experiments to gauge the necessary adjustment.

V Block: V blocks to give a uniform distribution of gamma and beta rays were used and also in an alternate experiment for the Alpha to the one shown when a fan shaped slit was required.

Dimensions of the Apparatus: For the Gamma experiment a 20 cm scale is indicated for a large apparatus, however for the Alpha and Beta experiments the estimated sizes

appear to be governed by a maximum range of 7 cms for an alpha particle so that the distance of the electrometer from the source is greater than this and accordingly the diameter of the Beta experiment hemisphere is estimated to be 12 cm. In the case of the Gamma experiment, domes are described, but with no idea of size.

Insulation and Screening: Sulphur was used as an excellent electrical insulator in ionisation chambers and resisted surface leakage caused by humidity and was used in the Alpha experiment. Iron and lead were used as screens to prevent unwanted gamma and beta particles getting into the ionisation chambers.

In the Alpha experiment the bottom gauze of the three (centre for measurement) could be made +ve or -ve at around 41 volts to control the entry of particles for measurement. In the case of the Beta experiment, the radium was covered by .002 cm of copper which reduced the alpha component of the emanation at that point which were blocked further by foils and air so as not be able to reach the electrometer.

In the Beta experiment aluminium was used to line the hemisphere.

Gauzes, Radiators and Foils: In all 3 experiments quite a large number (approximately 10) of each of these materials of different thickness and atomic weight could be positioned at different distances from the uranium or radium for measurements to be taken to identify the effect. Brass gauzes with an air to metal ratio of 1:1 were found to give early saturation and extensively used.

Secondary radiated gamma radiation was significantly more with a lead (Pb) radiator of high atomic weight.

The foils used in the Beta experiment were gold, silver, aluminium and carbon.

Seals: In the Alpha experiment mercury traps were used to maintain a tight seal.

Apertures: In the Alpha experiment the aperture was a 1 cm diameter round opening. For the Beta experiment a circular hole in the lead plate was approximately 1.6 cm in diameter.

Gas Flow: In the Alpha experiment the gas flow passing over the uranium was 10 cms/sec.

Voltages: In the Alpha experiment voltages on the bottom and top gauzes could be ranged from -40 to 500 volts.

Current: Arbitrary scales were used as a measure of the number of particles entering the ionisation chamber.

Distance to the Electrometer: For the Alpha experiment the distance was 3.5 cms, for Gamma experiment approximately 40 cms, and for Beta experiment approximately 6 cms.

Tables: For Alpha and Gamma experiments, result data is shown in 2 and 3 tables respectively.

Graphs: For the Alpha experiment 3 graphs are used, for Gamma experiment 9 graphs are used and for the Beta experiment 2 graphs are shown, in this case with data plots.

Ratios: For the Alpha experiment the main ratio was the air to metal proportion. For the Gamma experiment the ratio analysis was very significant including the ratio of secondary to primary intensity. For the Beta experiment, following on from Gamma, the ratio of more to less scattered particles proved very significant.

Reference to Similar Work: In each experiment reference is given to similar work which had been carried out overseas eg. By M de Broglie, A Eve and J A Crowther.

Date of Work: Estimated periods in which work was carried out are: Alpha 1906-07, Gamma 1908, Beta 1908 .

Summary of Results: For the Alpha experiment, which followed Rutherford's 1899 experiment with variations, the results of recombination of ions were similar indicating a very fast rate of recombination.

Results for the Gamma experiment appeared to indicate that 2 distinct homogeneous bundles were formed, the soft being 4 times that of the hard.

For the Beta experiment it was found that for the thinnest foils there was a constant ratio of more to less scattered particles indicating a single collision.

Publications: Alpha experiment is in a substituted DSc thesis in 1907 (The Ionisation remaining I gases after removal of the ionising agent)-TRSSA-April 1908.

Gamma experiment; Secondary gamma radiation. Phil Mag March 1909.

Beta experiment: The scattering of beta rays of radium-Phil Mag January 1909.

Footnote:

In 1899 Rutherford pointed out that there was great difficulty in producing complete saturation ie to reach a stage where all the ions produced reach the electrodes.

It wasn't until July 1907 that Rutherford and Geiger were able to get an accurate complete saturation using a vacuum with a measurement of the current and separately to get a count of the alpha particles to determine that the alpha particle was a helium atom with double the elementary electric charge.