newsletter

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Homage to Heinrich Hertz

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Figure 1: Heinrich Hertz, courtesy Wikipedia Commons

Hertz and the photo-electric effect

Heinrich Hertz (*Fig. 1*) in 1887, had been the first to observe the photo-electric effect, namely that shining ultra-violet light onto brass knobs (that were connected to a spark generator) greatly enhanced the production of the sparks between the knobs. When Hertz discovered that this was a property of ultra-violet light, he left it to others to take this forward as he was more concerned with experiments (described in *Part I*) to determine the correctness or otherwise of the rival theories of electricity, namely those of Maxwell, Weber and Neumann.

But it was the beginning of 'quantum theory' in physics. Albert Einstein would win his Nobel Prize for Physics in 1921 for the explanation of the photo-electric effect; namely that the energy of electromagnetic waves was proportional to their frequency. Ultra-violet light, having a higher frequency than visible light, had enough energy to knock electrons out of metals. This gave rise to the equation:

Energy of radiation=(a constant)×(frequency of the radiation).

Hertz moves from Karlsruhe to Bonn

By 1889, Hertz's fame had spread throughout the world. He moved to the University of Bonn to take up the prestigious Chair of Physics, previously held by Professor Clausius (1822–1888). Clausius was well known, along with Professor Helmholtz (1821–1894) and Lord Kelvin (1824–1907), for his work on *'the principle of conservation energy'.*

Rumford Medal of the Royal Society

In December 1890, in acknowledgement of his great experimental success, Hertz was awarded the Rumford Medal of the Royal Society when he visited London for the presentation. It was particularly appropriate to award this medal to Hertz as this medal had previously been awarded to Michael Faraday (in 1846) and to Clerk Maxwell (in 1860).

On this occasion, Hertz was introduced to Professors Lodge and Fitzgerald and other prominent members of the Royal Society who recognised that it was Hertz who had shown that Maxwell's theory of electromagnetism was correct. Hertz also received a congratulatory communication from Oliver Heaviside who had contributed to the theory of electromagnetism. At the celebratory dinner, Hertz delivered his speech in English as Hertz had a special gift for languages whether classical or modern, even Arabic.

During his London visit, Hertz was shown round the Royal Institution by its then Director Sir James Dewar[1]. Dewar described, to Hertz, the work of his predecessor, Michael Faraday (1791–1867).

1 Sir James Dewar, FRS, FRSE was for a short time a colleague of Clerk Maxwell at Cambridge before becoming Director of the Royal Institution.

Figure 2: The Old Cavendish Laboratory, courtesy of the James Clerk Maxwell Foundation

The Cavendish Laboratory

On the next day of his 1890 visit, Hertz visited the famous Cavendish Laboratory in Cambridge (*Fig 2*).

Maxwell had been the first 'Cavendish Professor of Physics' having previously been an undergraduate at Trinity College and later a Fellow (from 1851–56 and again on returning to Trinity College in 1871). He died in post in 1879 at the age of 48.

Lord Rayleigh (Nobel prize in 1906 for his discovery of the gas 'argon') had been the second Cavendish Professor. J.J. Thomson, who had been a research student at the Cavendish when Maxwell was alive, was appointed the third Cavendish Professor in 1884. It was Thomson who showed Hertz round the Cavendish Laboratory. Hertz and Thomson were of a similar age and had both been made professors at the age of 28. When Thomson had met Hertz in person, he had been much impressed by him.

Death of Hertz

In 1892, only two years after his visit to London, Hertz developed an infection and died in 1894 at the age of only thirty-six leaving a wife and two young daughters, aged one and five.

In a memorial tribute to Hertz, Professor Herman Ebert speaking before the Physical Society of Erlangen said:

"In him there passed away not only a man of great learning, but also a noble man, who had the singular good fortune to find many admirers, but none to hate or envy him; those who came into personal contact with him were struck by his modesty and charmed by his amiability. He was a true friend to his friends, a respected teacher to his students, who had begun to gather around him in somewhat large numbers, some of them coming from great distances; and to his family a loving husband and father."

Memorial address to Hertz delivered by Professor Herman Ebert, March, 1894

Practical applications of *'Hertzian waves'*

In 1888, although Hertz had begun the opening up the electromagnetic spectrum, he had not appreciated the number of practical applications of electromagnetic waves that would result in the near future.

The practical exploitation of electromagnetic waves was rapid.

Figure 3: Wilhelm Röntgen, courtesy Wikipedia Commons

In 1895, only some seven years after Hertz's famous experiments, Wilhem Röntgen (*Fig. 3*) had produced and detected X-rays (initially called 'Röntgen rays') part of the electromagnetic spectrum and Maxwell's *"..other radiations if any"*. These X-rays would, in due course, become indispensable to medicine. Röntgen won the Nobel Prize for Physics in 1901.

In 1897, Marconi set up his first electrical company thereby showing the potential of radio transmission (*Fig. 4*, where a Ruhmkorff coil can be seen on the right of the picture). Marconi was to win the 1909 Nobel Physics Prize for his work on radio transmission.

In June 1920, the first live public broadcast was made from Marconi's Wireless Telegraph Company. In 1927, the British Broadcasting Corporation received its Royal Charter and the year 1936 saw the start of television broadcasts.

The mere mention of light of different colours, radio-waves, micro-waves, mobile-phones, radio-astronomy, x-rays and gamma rays illustrates the profound significance for mankind of the progressive unveiling of the electromagnetic spectrum.

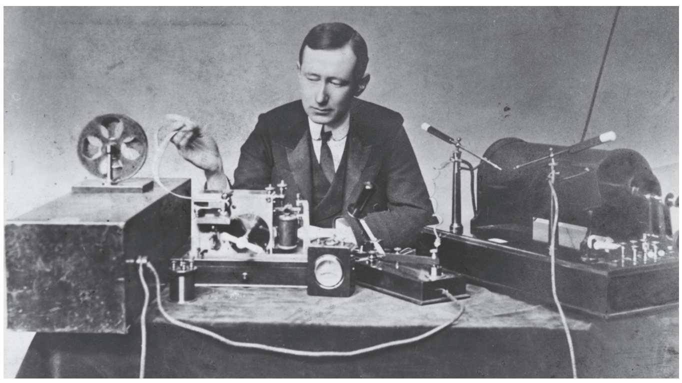

Figure 4: Marconi with his radio equipment, courtesy Wikipedia Commons

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J. J. Thomson and the Electron

Figure 5: J.J. Thomson, courtesy Wikipedia Commons

J. J. Thomson had won the 1906 Physics Nobel Prize for his discovery of the electron.

He had experimented with cathode rays which are streams of electrons observed in discharge tubes (where an electric current flows in a high vacuum between electrodes across which an electric potential difference has been applied). J. J .Thomson had showed that cathode rays were composed of previously unknown negatively charged particles (now called electrons). As J. J. Thomson said:

"As the cathode rays carry a charge of negative electricity, are deflected by an electrostatic force as if they were negatively electrified, and are acted on by a magnetic force in just the way in which this force would act on a negatively electrified body moving along the path of these rays, I can see no escape from the conclusion that they are charges of negative electricity carried by particles of matter."

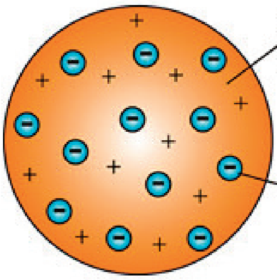

Figure 6: Thomson's 'plum pudding' model of the atom, courtesy Bing Images

J. J. Thomson's discovery of the electron changed the way people viewed atoms. Up until the end of the 19th century, atoms were thought to be tiny solid spheres. In 1903, J. J. Thomson proposed a model of the atom consisting of positive and negative charges, present in equal amounts so that an atom would be overall electrically neutral. He proposed the atom was a sphere, with the positive and negative charges embedded within it (*Fig 6*). Thomson's model was known as the 'plum pudding' model.

Today's picture is that atoms consist of a compact central nucleus of positively-charged protons and neutral neutrons, with negatively-charged electrons orbiting at a distance from the nucleus.

By 1936, J. J. Thomson had become the Master of Trinity College.

Hertz's widow and daughters

Figure 7: Heinrich and Elizabeth Hertz , courtesy of matidavid.com

Since 1923 and the collapse of German currency after the First World War, Elizabeth Hertz (the widow of Heinrich Hertz) had survived on the charity of various radio companies.

In 1936, Elizabeth Hertz and her two daughters (Johanna and Mathilde) by then aged 72, 49 and 45 respectively, fled from Germany because of rising antisemitism. This was despite the fact that the Hertz family was Lutheran; their connection with Judaism being distant.

Figure 8: Mathilde Hertz, courtesy Google Images

In Germany, Mathilde Hertz (1891–1975) had been a biologist and one of the first influential women scientists in the field of biology and a pioneer in the field of comparative psychology. Between 1925 and 1935, she published more than thirty articles. In England, she published an article on colour vision in bees and an article on vision in migratory locusts. Johanna Hertz (1887–1967) had been a doctor in Germany.

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With the help of Professors Max von Laue and Erwin Schrödinger, Mathilde found temporary refuge in Oxford but it was J. J. Thomson in Cambridge (who had met Hertz in 1890 and had been impressed by him) who helped her settle in Girton, a village near Cambridge. A little later Mathilde persuaded her mother and sister to join her. J. J. Thomson found Mathilde a job lecturing at Cambridge University. The Hertzs kept in touch with the Thomsons. J.J.'s grandson remembers meeting one of Hertz's daughters at Lady Thomson's house during the Second World War and being told how helpful his grandfather had been to the Hertzs.

Hertz's widow died in Girton in 1941 and was buried in an unmarked grave. The position of the grave was, however, marked in the parish register and was discovered many years later by the churchwarden. In 1992, a stone was dedicated in the churchyard over the previously unmarked grave.

The German Embassy provided a fitting mark in the form of a plain York stone. The dedication in the church was attended by Hertz's great-nephew, Gerhard Hertz, professor of physical chemistry at Karlsruhe, as well as many other scientists.

Hertz manuscript donated to Trinity

Although most of the papers of Professor Hertz were given to the 'Staatsmuseum' in Hamburg (being the city of his birth), Hertz's widow donated to the Wren Library at Trinity College, Hertz's own manuscript, in his own handwriting, of his famous 1887 paper presented to the Prussian Academy of Sciences in which he established the finite velocity of the Hertzian waves.

"Uber die Ausbreitungsgeschwindigkeit der elektrodynamischen Wirkungen".

(On the speed at which electromagnetic waves spread out)

You can see Hertz's handwritten manuscript at this link.[2] It seems likely that Hertz's widow donated this manuscript to Trinity College in recognition of the assistance that J. J. Thomson had given to her and her daughters.

Figure 9: Gustav Hertz, courtesy Wikipedia Commons

The Hertz tradition

The Hertz tradition in physics continues with the nephew of Heinrich Hertz (namely Gustav Hertz, *Fig. 9*) winning the Nobel Prize for Physics in 1925. One of Heinrich Hertz's great nephews was Gerhard Hertz (see earlier). Another was Carl Hellmuth Hertz who developed medical ultrasonography at the University of Lund in Sweden. Hertz's great-grand-nephew, Martin Hans Hertz, is also a physicist. In 1997, he was appointed professor in biomedical physics at KTH Royal Institute of Technology in Stockholm.

The Mexican Stamp

When Hertz concluded his experiments in 1888, Maxwell, if he had lived, would only have been fifty-seven years of age. As Maxwell did not live long enough to see Hertz's triumphal confirmation of his theory of electricity and magnetism, it is perhaps appropriate to end this Newsletter with the Mexican stamp commemorating both Hertz and Maxwell.

Mexican stamp, courtesy Wikipedia Commons

2 **https://mss-cat.trin.cam.ac.uk/Manuscript/O.11.2**