Heinrich Hertz

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Heinrich Rudolf Hertz (February 22, 1857 ï January 1, 1894) was a German physicist who clarified and expanded the electromagnetic theory of light that had been put forth by Maxwell. He was the first to satisfactorily demonstrate the existence of electromagnetic waves by building an apparatus to produce and detect VHF or UHF radio waves.

Heinrich Rudolf Hertz

Born	February 22, 1857 Hamburg
Died	January 1, 1894 (aged 36) Bonn, Germany
Residence	Germany
Nationality	German
Fields	Physics Electronic Engineering
Institutions	University of Kiel University of Karlsruhe University of Bonn
Alma mater	University of Munich University of Berlin
Doctoral advisor	Hermann von Helmholtz
Known for	Electromagnetic radiation Photoelectric effect

Signature

Contents

Biography

Early years

Hertz was born in Hamburg, Germany, into a prosperous and cultured Hanseatic family. His father, Gustav Ferdinand Hertz, was a barrister and later a senator. His mother was the former Anna Elisabeth Pfefferkorn. He had three younger brothers and one younger sister.[1]

While studying at the Gelehrtenschule des Johanneums of Hamburg, he showed an aptitude for sciences as well as languages, learning Arabic and Sanskrit. He studied sciences and engineering in the German cities of Dresden, Munich and Berlin, where he studied under Gustav R. Kirchhoff and Hermann von

Helmholtz.

In 1880, Hertz obtained his PhD from the University of Berlin; and remained for post-doctoral study under Helmholtz.

In 1883, Hertz took a post as a lecturer in theoretical physics at the University of Kiel.

In 1885, Hertz became a full professor at the University of Karlsruhe where he discovered electromagnetic waves.

Meteorology

Hertz always had a deep interest in meteorology probably derived from his contacts with Wilhelm von Bezold (who was Hertz's professor in a laboratory course at the Munich Polytechnic in the summer of 1878). Hertz, however, did not contribute much to the field himself except some early articles as an assistant to Helmholtz in Berlin, including research on the evaporation of liquids, a new kind of hygrometer, and a graphical means of determining the properties of moist air when subjected to adiabatic changes.[2]

Contact mechanics

Memorial of Heinrich Hertz on the campus of the University of Karlsruhe

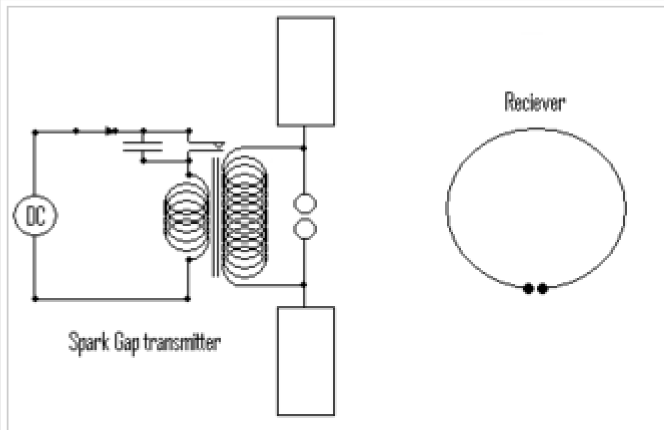
In 1881ï 1882, Hertz published two articles on what was to become known as the field of contact mechanics. Hertz is well known for his contributions to the field of electrodynamics (*see below*); however, most papers that look into the fundamental nature of contact cite his two papers as a source for some important ideas. Joseph Valentin Boussinesq published some critically important observations on Hertz's work, nevertheless establishing this work on contact mechanics to be of immense importance. His work basically summarises how two axi-symmetric objects placed in contact will behave under loading, he obtained results based upon the classical theory of elasticity and continuum mechanics. The most significant failure of his theory was the neglect of any nature of adhesion between the two solids, which proves to be important as the materials composing the solids start to assume high elasticity. It was natural to neglect adhesion in that age as there were no experimental methods of testing for it.

To develop his theory Hertz used his observation of elliptical Newton's rings formed upon placing a glass sphere upon a lens as the basis of assuming that the pressure exerted by the sphere follows an elliptical distribution. He used the formation of Newton's rings again while validating his theory with experiments in calculating the displacement which the sphere has into the lens. K. L. Johnson, K. Kendall and A. D. Roberts (JKR) used this theory as a basis while calculating the theoretical displacement or *indentation depth* in the presence of adhesion in their landmark article "Surface energy and contact of elastic solids" published in 1971 in the Proceedings of the Royal Society (A324, 1558, 301-313). Hertz's theory is recovered from their formulation if the adhesion of the materials is assumed to be zero. Similar to this theory, however using different assumptions, B. V. Derjaguin, V. M. Muller and Y. P. Toporov published another theory in 1975, which came to be known as the DMT theory in the research community, which also recovered Hertz's formulations under the assumption of zero adhesion. This DMT theory proved to be rather premature and needed several revisions before it came to be accepted as another material contact theory in addition to the JKR theory. Both the DMT and the JKR theories form the basis of contact mechanics upon which all transition contact models are based and used in material parameter prediction in Nanoindentation and Atomic Force Microscopy. So Hertz's research from his days as a lecturer, preceding his great work on electromagnetism, which he himself considered with his characteristic soberness to be trivial, has come down to the age of nanotechnology.

Electromagnetic research

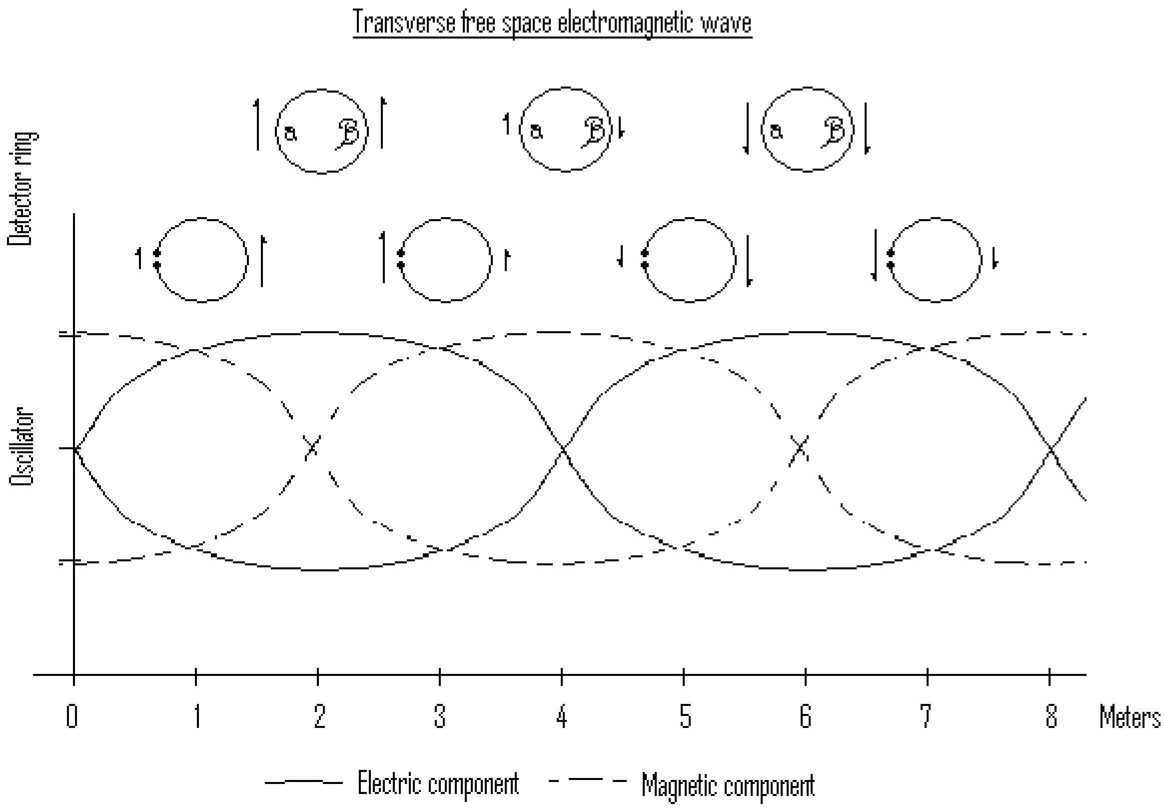
Hertz helped establish the photoelectric effect (which was later explained by Albert Einstein) when he noticed that a charged object loses its charge more readily when illuminated by ultraviolet light. In 1887, he made observations of the photoelectric effect and of the production and reception of electromagnetic (EM) waves, published in the journal Annalen der Physik. His receiver consisted of a coil with a spark gap, whereupon a spark would be seen upon detection of EM waves. He placed the apparatus in a darkened box to see the spark better. He observed that the maximum spark length was reduced when in the box. A glass panel placed between the source of EM waves and the receiver absorbed ultraviolet radiation that assisted the electrons in jumping across the gap.

When removed, the spark length would increase. He observed no decrease in spark length when he substituted quartz for glass, as quartz does not absorb UV radiation. Hertz concluded his months of investigation and reported the results obtained. He did not further pursue investigation of this effect, nor did he make any attempt at explaining how the observed phenomenon was brought about.



1887 experimental setup of Hertz's apparatus.

Earlier in 1886, Hertz developed the **Hertz antenna** receiver. This is a set of terminals that is not electrically grounded for its operation. He also developed a transmitting type of dipole antenna, which was a center-fed driven element for transmitting UHF radio waves. These antennas are the simplest practical antennas from a theoretical point of view. In 1887, Hertz experimented with radio waves in his laboratory. These actions followed Michelson's 1881 experiment (precursor to the 1887 Michelson-Morley experiment) which did not detect the existence of aether drift, Hertz altered the Maxwell's equations to take this view into account for electromagnetism. Hertz used a Ruhmkorff coil-driven spark gap and one meter wire pair as a radiator. Capacity spheres were present at the ends for circuit resonance adjustments. His receiver, a precursor to the dipole antenna, was a simple half-wave dipole antenna for shortwaves.



Through experimentation, he proved that transverse free space electromagnetic waves can travel over some distance. This had been predicted by James Clerk Maxwell and Michael Faraday. With his apparatus configuration, the electric and magnetic fields would radiate away from the wires as transverse waves. Hertz had positioned the oscillator about 12 meters from a zinc reflecting plate to produce standing waves. Each wave was about 4 meters. Using the ring detector, he recorded how the magnitude and wave's component direction vary. Hertz measured Maxwell's waves and demonstrated that the velocity of radio waves was equal to the velocity of light. The electric field intensity and polarity was also measured by Hertz. (Hertz, 1887, 1888).

The Hertzian cone was first described by Hertz as a type of wave-front propagation through various media. His experiments expanded the field of electromagnetic transmission and his apparatus was developed further by others in the radio. Hertz also found that radio waves could be transmitted through different types of materials, and were reflected by others, leading in the distant future to radar.

Hertz did not realize the practical importance of his experiments. He stated that,

> "*It's of no use whatsoever*[...] *this is just an experiment that proves Maestro Maxwell was right - we just have these mysterious electromagnetic waves that we cannot see with the naked eye. But they are there.*" [3]

Asked about the ramifications of his discoveries, Hertz replied,

> "*Nothing, I guess*." [3]

His discoveries would later be more fully understood by others and be part of the new "wireless age". In bulk, Hertz' experiments explain reflection, refraction, polarization, interference, and velocity of electric waves.

In 1892, Hertz began experimenting and demonstrated that cathode rays could penetrate very thin metal foil (such as aluminium). Philipp Lenard, a student of Heinrich Hertz, further researched this "ray effect". He developed a version of the cathode tube and studied the penetration by X-rays of various materials. Philipp Lenard, though, did not realize that he was producing X-rays. Hermann von Helmholtz formulated mathematical equations for X-rays. He postulated a dispersion theory before Röntgen made his discovery and announcement. It was formed on the basis of the electromagnetic theory of light (*Wiedmann's Annalen*, Vol. XLVIII). However, he did not work with actual X-rays.

Death at age 36

In 1892, an infection was diagnosed (after a bout of severe migraines) and Hertz underwent some operations to correct the illness. He died of Wegener's granulomatosis at the age of 36 in Bonn, Germany in 1894, and was buried in Ohlsdorf, Hamburg at the Jewish cemetery.[4]

Hertz's wife, Elizabeth Hertz (maiden name: Elizabeth Doll), did not remarry. Heinrich Hertz left two daughters, Joanna and Mathilde. Subsequently, all three women left Germany in the 1930s to England, after the rise of Adolf Hitler. Charles Susskind interviewed Mathilde Hertz in the 1960s and he later published a book on Heinrich Hertz. Heinrich Hertz's daughters never married and he does not have any descendants, according to the book by Susskind.

Legacy

His nephew Gustav Ludwig Hertz was a Nobel Prize winner, and Gustav's son Carl Hellmuth Hertz invented medical ultrasonography.

The SI unit *hertz* (Hz) was established in his honor by the IEC in 1930 for frequency, a measurement of the number of times that a repeated event occurs per unit of time (also called "cycles per sec" (cps)). It was adopted by the CGPM (Conférence générale des poids et mesures) in 1964.

In 1969 (East Germany), there was cast a Heinrich Hertz memorial medal. The IEEE Heinrich Hertz Medal, established in 1987, is "*for outstanding achievements in Hertzian waves* [...] *presented annually to an individual for achievements which are theoretical or experimental in nature*".

A crater that lies on the far side of the Moon, just behind the eastern limb, is named in his honor. The Hertz market for radioelectronics products in Nizhny Novgorod, Russia, is named after him. The Heinrich-Hertz-Turm radio telecommunication tower in Hamburg is named after the city's famous son.

Nazi revisionism

Although Hertz would not have considered himself Jewish, his "Jewish" portrait was removed by the Nazis from its prominent position of honor in Hamburg's City Hall (*Rathaus*) because of his partly "Jewish ancestry." Hertz was a Lutheran; and although his fatherœs family had been Jewish,[1] his father had been converted to Catholicism before marrying.[3] The painting has since been returned to public display.[5]

Honors

Hertz was honored by Japan with the Order of the Sacred Treasure.[6]

See also

People

- Hans Christian Ørsted
- David Edward Hughes
- Reginald Aubrey Fessenden
- Guglielmo Marconi
- Gustav Ludwig Hertz
- Hermann von Helmholtz
- James Clerk Maxwell
- Nikola Tesla
- Wilhelm Röntgen

Lists and histories

- Electromagnetism timeline
- Timeline of mechanics and physics
- List of physicists
- Radio history
- Wireless telegraphy
- List of people on stamps of Germany
- List of physics topics

Electromagnetic radiation

- Dipole antenna
- Microwave
- Luminiferous aether

Other

- University of Bonn
- University of Karlsruhe
- Radio
- Heinrich-Hertz-Turm
- German inventors and discoverers

Notes

1. ^ ***a b*** Koertge, Noretta. (2007). *Dictionary of Scientific Biography,* Vol. 6, p. 340.
2. ^ Mulligan, J. F., and H. G. Hertz, "On the energy balance of the Earth," *American Journal of Physics*, Vol. 65, pp. 36-45.
3. ^ ***a b c*** Institute of Chemistry, Hebrew University of Jerusalem: Hertz biography, digitized photographs
4. ^ For a photograph of his gravesite, see "Heinrich Rudolf Hertz". http://phisicist.info/hertz.html. Retrieved 2008-12-02.
5. ^ Robertson, Struan: Hertz biography
6. ^ L'Harmattan: List of recipients of Japanese Order of the Sacred Treasure (in French)

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External links

- Hertzian radiation - better known as radio waves: what it is and how it happens
- *Encyclopedia Britannica* (1911): Hertz biography

Categories: 1857 births | 1894 deaths | German physicists | German philosophers | German Jews | Jewish scientists | Telecommunications history | German-language philosophers | German inventors | People from Hamburg | Technical University of Munich alumni | Humboldt University of Berlin alumni | University of Bonn faculty | University of Karlsruhe faculty | University of Kiel faculty | Radio pioneers