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Hendrik Antoon Lorentz: his role in physics and society

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Abstract
Hendrik Antoon Lorentz (1853–1928) was appointed in 1878 to a chair of theoretical physics at the University of Leiden, one of the first of such chairs in the world. A few years later Heike Kamerlingh Onnes became his experimental colleague, after vehement discussions in the faculty. Lorentz strongly supported Kamerlingh Onnes then, and proved subsequently to be an ideal colleague. With Lorentz's electron theory the classical theory of electromagnetism obtained its final form, at the time often called the Maxwell–Lorentz theory. In this theory the Zeeman effect could be explained: the first glimpse of the electron. The Nobel Prize followed in 1902. The Lorentz transformation, established in 1904, preceded the special theory of relativity. Later on, Lorentz played a much admired role in the debate on the new developments in physics, in particular as chairman of a series of Solvay conferences. Gradually his stature outside of physics grew, both nationally as chairman of the Zuiderzee committee and internationally as president of the International Commission on Intellectual Cooperation of the League of Nations. At his funeral the overwhelming tribute was the recognition of his unique greatness. Einstein said about him 'He meant more to me personally than anyone else I have met on my life's journey'.

1. Introduction

Lorentz (figure 1) was active as a scientist for over 50 years. After establishing his reputation in academic circles, he developed into one of the world's greatest authorities on physics of his day. In the latter years of his life, he became a national celebrity in the Netherlands. His special blend of understanding, knowledge, tact and charm made him famous and admired among his contemporaries. Einstein mentioned the impression Lorentz made on him several times in private correspondence, and declared his admiration publicly on the 100th anniversary of Lorentz's birth in 1953 as follows: 'He meant more to me personally than anyone else I have met on my life's journey'.

All this was of course unforeseeable when Lorentz was born to a prosperous horticulturalist in Arnhem in 1853. Lorentz arrived in a world with a positive outlook on the natural sciences, an optimism that sometimes induced private individuals and institutions to invest in research. In the Netherlands, new educational legislation was being prepared. It was an atmosphere in which long-term concentration on a single scientific goal or programme was possible, and dedicated researchers had the backing of university governors. There were still very few 'professional' physicists, those who were employed by universities or polytechnic schools and had occasional opportunities to do some research. The world total has been estimated at something between 1200 and 1500. By way of comparison, the number of professional physicists in the 1990s was about 150 thousand globally.

This was the world in which Lorentz found his way. For the first 25 years his base of action was mainly in Arnhem, in the following 25 years it was in Leiden, and during the last 25 years of his life he became increasingly a national and international celebrity.

2. Lorentz's entry into physics

Teenagers of Lorentz's generation were the first to benefit from a new form of secondary education introduced by Dutch legislation in 1863, the HBS. The curriculum was of a more practical character than that of the gymnasia, whose function was primarily to prepare pupils for university. It turned out to be the HBS students who (with supplementary education in the mandatory classical languages) would go on to study exact sciences at university. Out of eight Dutch Nobel Prize winners in the exact sciences in the period from 1901 to 1940, seven had enjoyed their secondary education at HBS schools and one, van der Waals, born too early for HBS, reached university armed

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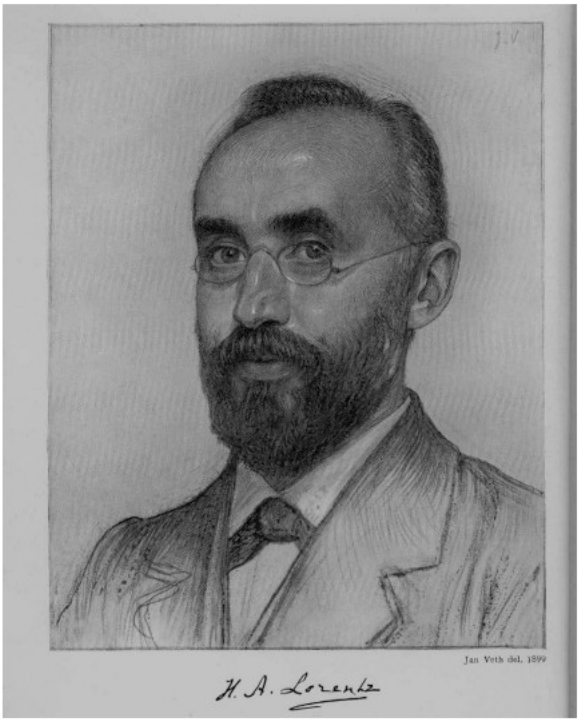

Figure 1. Lorentz in 1899, drawing by Jan Veth., collection Instituut Lorentz, Leiden. Reproduced with permission.

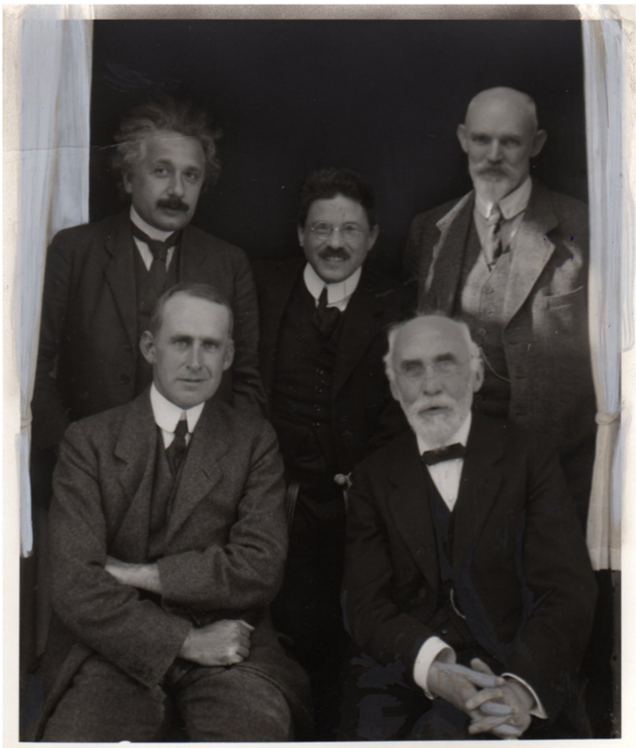

Figure 2. Picture, taken in 1923 in Leiden with clockwise Lorentz, Eddington, Einstein, Ehrenfest and de Sitter, collection Academic Historical Museum Leiden. Reproduced with permission.

only with an education at the earlier MULO secondary school and teaching diplomas.

Lorentz went to the newly opened HBS in 1866 and went directly into the third grade where there were so far only two other pupils. The teachers at the Arnhem HBS were of exceptional calibre. The physics teacher was van de Stadt, who had studied at Leiden University and would later write a school textbook on physics which was to continue in use for decades. He also popularized science through newspaper articles and lectures; the lectures were given to scientific societies such as ‘Wessel Knoops’ in Arnhem and ‘Diligentia’ in The Hague, where he lectured six times. Lorentz, incidentally, was later to deliver 16 lectures to Diligentia. The chemistry teacher, appointed in 1868, was Van Bemmelen who came from Groningen where he had taught another highly promising pupil, Kamerlingh Onnes. Van Bemmelen introduced these two talented young men to each other in their early student years—a coincidental acquaintanceship which may well have contributed to subsequent scientific developments.

In 1870, Lorentz went to study at Leiden University. The astronomer Kaiser, informed by van de Stadt of the imminent arrival of a highly gifted student, decided to resume the lecture class which he had stopped owing to lack of interest. There was now at least one student, Lorentz, who consequently enjoyed what was practically private tutelage. Lorentz was later to become closely acquainted with the Kaiser family, eventually leading to his marriage with Aletta Kaiser, the astronomer’s niece. After taking his *kandidaats* examination in 1872, Lorentz returned to his parental home in Arnhem. He was to remain there until 1878, preparing firstly for his *doctoraal* (a first degree roughly equivalent to MSc) and then for a doctorate, which he was awarded on 11 December 1875 (a Saturday, not unusual in those days). He had meanwhile also been teaching evening classes in mathematics since he was 19 years old.

While Lorentz was gradually building up his knowledge of physics in both breadth and depth, an important change took place in the Dutch universities. A new higher education law was passed in 1876, with immediate implications for several physicists. Among other things, the Athenaeum Illustre school in Amsterdam gained university status and thus needed to appoint a professor of physics, while the existing chair of physics in Leiden was split in two. The incumbent Professor Rijke continued to occupy the Leiden chair of Experimental Physics, and a candidate was sought for the new chair of Mathematical Physics. Rijke thought in the first instance of his former student van der Waals, but the latter opted to go to Amsterdam. The choice thus fell on his other brilliant student, the younger Lorentz. He was appointed and, not yet 25 years old, held his inaugural lecture in early 1878 on the subject of ‘Molecular theories in physics’. The chair in theoretical physics, now occupied by Lorentz, was not only the first in the Netherlands but one of the first worldwide. Lorentz was to set an exemplary standard in the way he fulfilled his novel teaching and research remit. University chairs of this kind are now commonplace. The public mood was favourable in the Netherlands at the time, and the national budget for higher education was doubled in 1878. This meant more staff and better salaries, so giving the professors the necessary time and resources to conduct research. When

Rijke retired, a new candidate had to be sought for the chair of experimental physics. The faculty was strongly divided over the shortlist. Van Bemmelen, the former high school teacher, who had already been a Leiden professor for several years, and Lorentz both favoured Kamerlingh Onnes. He was eventually appointed, and in 1882 Kamerlingh Onnes was able to start his programme of cryogenic research. The faculty now had a dream team: Kamerlingh Onnes set up a modern laboratory equipped for large-scale research, while Lorentz brought classical physics to its culmination. Indirectly Lorentz contributed to the laboratory's success. Since Kamerlingh Onnes' health was poor, he had to be careful in spending his energy. Therefore Lorentz took over his colleague's considerable teaching load for medical students. This he would do for about 20 years until a third professor of physics was appointed. The creation of this new chair in experimental physics was prompted by a tempting offer of the Munich chair of theoretical physics to Lorentz. From the scientific point of view, Lorentz's research would inspire the Leiden laboratory's successful magneto-optical research at a time when the cryogenic research had to be built up. How did Lorentz arrive at his achievements; what challenges faced him in the physics of the 19th century?

3. Aspects of 19th century physics

A number of physical phenomena which had been seen as completely disconnected in the early 1800s, came to be perceived later in the century as interrelated. It is fascinating to retrace this theoretical unification.

Firstly, there was the phenomenon of light. Newton thought light consisted of particles, while Huygens thought it consisted of waves. The experiments of Young and Fresnel in the early years of the 19th century, which demonstrated the interference of light, recruited an increasing following for the wave theory. But what kind of waves were they? Were they like sound waves, in which the density of air changes continually in the direction of propagation, or like water waves in which the vibration is perpendicular to the direction of propagation? Were they, in the language of physics, longitudinal or transverse waves? Transverse, Young and Fresnel argued, since that explained a remarkable phenomenon, that of polarized light. But what was it that vibrated? The hypothetical vibrating medium was called the ether. To sustain transverse waves, the ether had to possess the property of elasticity. The ether hypothesis raised many questions about the nature of the medium, however, for example as regards its density and penetrability. Was the ether moreover omnipresent, and did it move along with the earth or remain stationary? Both the questions and the answers were manifold, and led to a spate of 'undulation' theories. Alongside these theories, an entirely different theory emerged in 1862 when Maxwell stated: 'We can scarcely avoid the inference that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena.' In other words, he proposed the existence of electromagnetic ether instead of the elastic substance of the undulation theories. Maxwell came to this conclusion after working out the equations for electrical and magnetic phenomena and observing that both phenomena propagate with the same speed as light. An electromagnetic field expanded as a wave through the ether.

A very long road had been travelled in the knowledge of electricity and magnetism before Maxwell arrived at his theory. The names given to these phenomena date back to antiquity, but they had not been quantified in any way until around 1785 when Coulomb, a French military engineer, succeeded in measuring the strength of the forces between electric charges and of the magnetic forces between magnets. The electrical phenomena related to static charges, for Coulomb had no knowledge of electric currents. That knowledge only became available after 1800, when Volta invented a battery capable of delivering a continuous current.

The most shocking discovery in the study of electric currents was that made by the Danish scientist Oersted, who noticed in 1819 that an electric current caused the deflection of a nearby compass needle. New developments then followed in rapid succession. In 1820 Ampère proposed laws for the forces between two electric currents. A wound wire—a solenoid—proved to behave like a magnet as soon as a current was passed through it. Henceforth two previously wholly separate fields of investigation became united in a single discipline, that of electromagnetism. The English scientist Faraday discovered yet more effects, among them the generation of an electric current by a moving magnet—the principle of the dynamo.

By 1864, Maxwell succeeded in bringing a little order into the profusion of electromagnetic phenomena. One set of differential equations was enough to describe them all: charges and currents cause the propagation of fields, which in turn exert forces on charges and currents. Maxwell's theory appeared in book form in 1873, around the time Lorentz was starting out on his doctoral research. The undulation theories of light were at that moment in competition with Maxwell's theory, which interpreted light as an electromagnetic wave. People found the new theory hard to understand despite the publication of Maxwell's book, as is apparent from Ehrenfest's later characterization of the field as 'a kind of intellectual jungle, almost impenetrable in its virgin fertility'. Or, as Lorentz later recalled, 'It was not always easy to grasp Maxwell's ideas, and one sensed a lack of unity in his book, attributable to the fact that it faithfully followed his gradual transition from the old ideas to the new'.

Lorentz now made it the objective of his thesis to elaborate on the various theories describing the reflection and refraction of light. It was no small task but he succeeded, and concluded that Maxwell's theory was to be preferred. He rounded off his thesis with a list of optical phenomena, such as light dispersion by a glass prism, which would need to be reconsidered from a Maxwellian standpoint. He thus proposed a definite programme of research, and it was one which he would largely carry it out in later years. In this research he treated matter as particulate in nature, an outlook that received greater resonance in the Netherlands than in some other countries. He conducted research in other areas, too, but following the historic discovery by Hertz in 1888 of radio waves, whose existence Maxwell had predicted, Lorentz concentrated fully on electromagnetism once more. Gradually, a well-rounded picture was emerging.

Lorentz interpreted both charges and currents as particulate, a topic on which Maxwell had not gone into detail. He regarded an electric charge as a local deficiency or surplus of small charged particles, later to be called electrons. Currents consisted in this view of moving electrons. The electrons caused electromagnetic fields, which could in turn act on stationary or moving charged particles. He used the notion of stationary ether, and drew a sharp distinction between ether and matter. He also supplemented Maxwell's equations with an additional equation to describe the force exerted by an electromagnetic field on moving charges: the Lorentz force. In short, he clarified Maxwell's theory, refined its concepts and expanded its theoretical scope. Einstein would later refer to it as the Maxwell–Lorentz theory.

This line of thinking reached its definitive form in 1909 with the publication of the book *The Theory of Electrons*, one of the classics of physics. It is clear that the presence of this theoretical knowledge in Leiden created a fertile environment for experimental research on electromagnetic and optical phenomena, a line of research which existed alongside the main programme aimed at the liquefaction of helium. One of the faculty's researchers who obtained some experience of electromagnetic and optical phenomena as part of his doctoral studies was Zeeman. He obtained his PhD in 1893.

4. The Zeeman effect

According to Zeeman's own account, during his doctoral studies he once tried to discover whether a magnetic field had any influence on the lines of the spectrum of light emitted by an incandescent substance. No result was observed. A few years later, in September 1896, he decided on a new attempt to reveal this effect, since the laboratory now possessed new apparatus which could very accurately measure the positions of spectral lines.

Zeeman heated common salt using a Bunsen burner and passed the flame between the poles of an electromagnet. He measured a highly specific spectral line of sodium with the magnetic field turned respectively on and off. There did appear to be an effect: the thin spectral line was slightly widened by the magnetic field. He wrote a paper on the topic, and his findings were made public by the Royal Netherlands Academy of Arts and Sciences in Amsterdam on 31 October that year. Lorenz was able to explain the observed effect almost immediately in terms of his theories. Light was being emitted due to the vibrations of small, charged particles. The presence of the magnetic field meant that the particles were subject to the Lorentz force, thereby altering the frequency of their vibration and hence affecting the character of the emitted light. The single line would, Lorentz believed, be split into three, but the still limited accuracy of Zeeman's measurement meant the effect was only visible as a widening of the line. Lorentz moreover predicted that the light on either edge of the widened line would be differently polarized.

Zeeman confirmed these predictions in a further measurement session and announced the findings in a second publication. His paper compared the measured values of the phenomenon with the predicted values, and obtained from this comparison information on the electrical charge (e) and the mass (m) of the vibrating particles. The charge was clearly negative, and the charge–mass ratio e/m turned out to be a thousand times as great as the value that particles were then believed to possess. These particles had to be either a thousand times lighter in mass than a hydrogen atom, or carry a vastly greater charge than a hydrogen ion. It was Thomson who was later first to interpret the rays produced in a vacuum tube as beams of negatively charged particles. He measured the same e/m ratio, and later also measured the charge separately and hence derived the mass, which indeed proved to be a good thousand times less than that of a hydrogen atom. Thomson is therefore customarily regarded as the discoverer of the electron. When a particle can be said to be 'discovered' depends, however, on how it is defined and especially on what is actually measured. Be that as it may, it was Zeeman who was first to observe a manifestation of electrons and it was Lorentz who interpreted his findings in terms of the particles already predicted by his theory.

Lorentz's work gained wider recognition, and in 1897 he spoke about it for the first time before an audience abroad in Düsseldorf, Germany. It was not until 1900 that the first international physics conference took place in Paris. Lorentz was one of the speakers there. International contacts developed, and the Nobel Prize awarded to Lorentz and Zeeman in 1902 understandably contributed to Lorentz's growth into an internationally recognized figure.

5. The Nobel prize

The Nobel prize award ceremony of 1902 took place on Wednesday 10 December. The occasion was front page news in the Dutch daily *De Telegraaf*, but not until 15 December. The newspaper reported the ceremony and the considerations of the jury. Biographical information on the persons concerned was not revealed to the readers until the Sunday edition of 20/21 December. Of Lorentz, *De Telegraaf* wrote: 'This hero of science, who upholds the honour of our fatherland and whose great achievements in this peaceful struggle for the welfare of mankind have recently been recognized and celebrated in the land of the midnight sun, first saw the light of day in Arnhem in 1853'. This resounding opening sentence was followed by a concise report of his life and work. The rhetoric of heroism and struggles may sound rather dated, but at least it suggests a greater respect for practitioners of the exact sciences than is now sometimes expressed by the dismissive label of 'nerd'.

6. Into the 20th century

The first quarter of the 20th century was a time of revolutionary changes in physics: the special and general relativity theories, and quantum mechanics. Lorentz was on the one hand the last great representative of classical physics, but on the other he was a participant in the discourse on the new ideas. In the case of the special theory of relativity this was no more than logical, because the theory related to a problem which was of intense concern to Lorentz. The question was whether the speed of light for an observer travelling in the same direction as the light was different to that experienced by an observer travelling in the opposite direction. The experiment of Michelson and Morley measured no difference in the speed of light. Lorentz was able to explain this largely by introducing a hypothesis in which a measured length changes for moving observers. In 1904, Lorentz formulated a transformation of the frame of reference from a moving to a stationary observer. Not only length but also time were now modified by this transformation. If nature indeed behaved according to these hypothetical relations, then the speed of light would be exactly the same for any observer. In this way, Lorentz 'repaired' the classical theory.

Einstein entered the scene with his special theory of relativity the following year. This theory radically changed the classical concepts of space and time, and had no need of ether to do so. The above-mentioned Lorentz transformation survived, although now as a logical consequence of Einstein's theory, so the consequences of Lorentz's reasoning remained valid. Lorentz continued to accept the existence of the ether, although the new generation dispensed with it.

That Lorentz also continued to play an important part in the discourse outside the scope of relativity theory is clear from articles, lectures and correspondence. The letters he exchanged with Planck discuss the latter's idea that light of a given wavelength is transmitted in discrete packets or 'quanta' with a specific amount of energy. It was an idea that could explain experiments but was irreconcilable with the classical electron theory, as was gradually being realized. The recognition that Planck's theory of quanta was something new made particular headway in physics circles after the first Solvay Conference in 1911. Lorentz chaired this conference, as he did the following four. The Belgian industrialist Solvay had made funds available for a small, selected group of physicists to hold scientific congresses. Two such gatherings took place before the First World War; after these, physicists from Germany and Austria were barred from attendance. Lorentz tried to annul the ban and to seek reconciliation, as he did in other international physics organizations. He finally succeeded in getting the Germans and Austrians readmitted in 1927. The legendary Solvay Conference of that year was dedicated to quantum mechanics, which had been developed step by step from Planck's theory of quanta by a number of physicists, among them Einstein and Bohr. Lorentz's role as the chairman of the Solvay conferences was renowned. A passage from a letter from Kamerlingh Onnes to his laboratory curator, written at the 1911 conference, illustrates this: 'The meeting held here, which they call a '*conseil*', has been a great success. It's also been a huge success for Prof. Lorentz, who has excelled in the task and has won everyone's heart. It's been marvellous to see how nobody can find enough words for the exceptional clarity, facility and friendliness with which he has been able to lead us and, whenever there is any difference of opinion, to create and maintain such a pleasant, amicable and cheerful yet serious tone. In short, it's something else we Dutch may be proud of'.

As a participant in the new developments, Lorentz found himself overloaded with distracting university duties, so a job offer by a private institution in Haarlem held out a tempting alternative. He was able to reduce his university commitment to a part-time professorship, while accepting two much less demanding posts in Haarlem, one as curator of the Physics Cabinet of Teyler's Stichting and later a second as secretary of the Hollandsche Maatschappij der Wetenschappen (Holland Society of Sciences and Humanities). The benefit for Lorentz was clear. As a part-time professor at Leiden, he would continue giving only one course of lectures, the famous Monday morning lectures, before an audience of staff and advanced students. The subjects of these lectures covered practically all the new developments in physics. A few of the lectures were worked up by students into books, first in Dutch and then in other languages. It is noteworthy that he would sometimes lecture about a theory very soon after it had emerged. The matrix mechanics of Heisenberg were discussed in the academic year 1925–26, for example, and similarly Schrödinger's theory in 1927. Both versions of quantum mechanics were thus discussed a mere year after their introduction—and that was by someone already over seventy years old. He lectured on Einstein's theory of gravity as early as 1913–1914, while the theory was still under development.

Another benefit of Lorentz's new situation was that the faculty could retain his services but also offer an appointment to a successor. Lorentz tried to attract Einstein, but he had just accepted a post in Zurich and was moreover relieved not to have to follow in the footsteps of such a world-famous scientist. He then chose Ehrenfest, an inspiring, passionate and witty lecturer who was capable of penetrating to the heart of a problem and making the most difficult matters comprehensible. Ehrenfest was an unconventional man who preferred the Socratic paradigm of discussion and who fostered a creative climate with many young foreign visitors who were playing a revolutionary part in physics. Lorentz and Ehrenfest established a congenial relationship despite the wide disparity of character and the 27-year age difference.

Many discussions took place between them, for example when Einstein's theory of gravity was revealed in its definitive form on 25 November 1915, and they both attempted to understand it. The general theory of relativity was the subject of extensive exchanges between Einstein, Lorentz and Ehrenfest. This correspondence has been preserved, including a letter dated 10/11 January 1916 in which Lorentz informed Ehrenfest that he now understood Einstein's theory of the previous 25 November, and that he had written to Einstein to congratulate him. Ehrenfest replied: 'Your remark—I have congratulated Einstein with his brilliant results—has the same meaning for me as when one freemason recognizes another by exchanging a secret sign'. Ehrenfest was then still occupied with a critical evaluation of the theory, but it all became much clearer to him after receiving a new letter from Lorentz. He promptly requested Lorentz to dedicate his Monday morning lecture to the general relativity theory. Amongst the listeners was the astronomer de Sitter, who would publish papers on the subject. Leiden was to become an active centre of research in this area for a number of years (figure 2). Einstein was gratified with Lorentz's compliments, as is clear from a letter of 17 January 1916. Shortly after completion of the theory, Einstein was not yet world famous: that only came about when the predicted bending of light by the attractive force of the


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prof einstein huberlandstrasze 5

berlin =

Telegramm Nr.

Telegraphie des Deutschen Reichs.

Berlin, Haupt Telegraphenamt

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Telegramm aus bln sgravenhage 0046 21/19 22/9 10.40

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Figure 3. Telegram, now in possession of Museum Boerhaave, Leiden. Reproduced with permission.

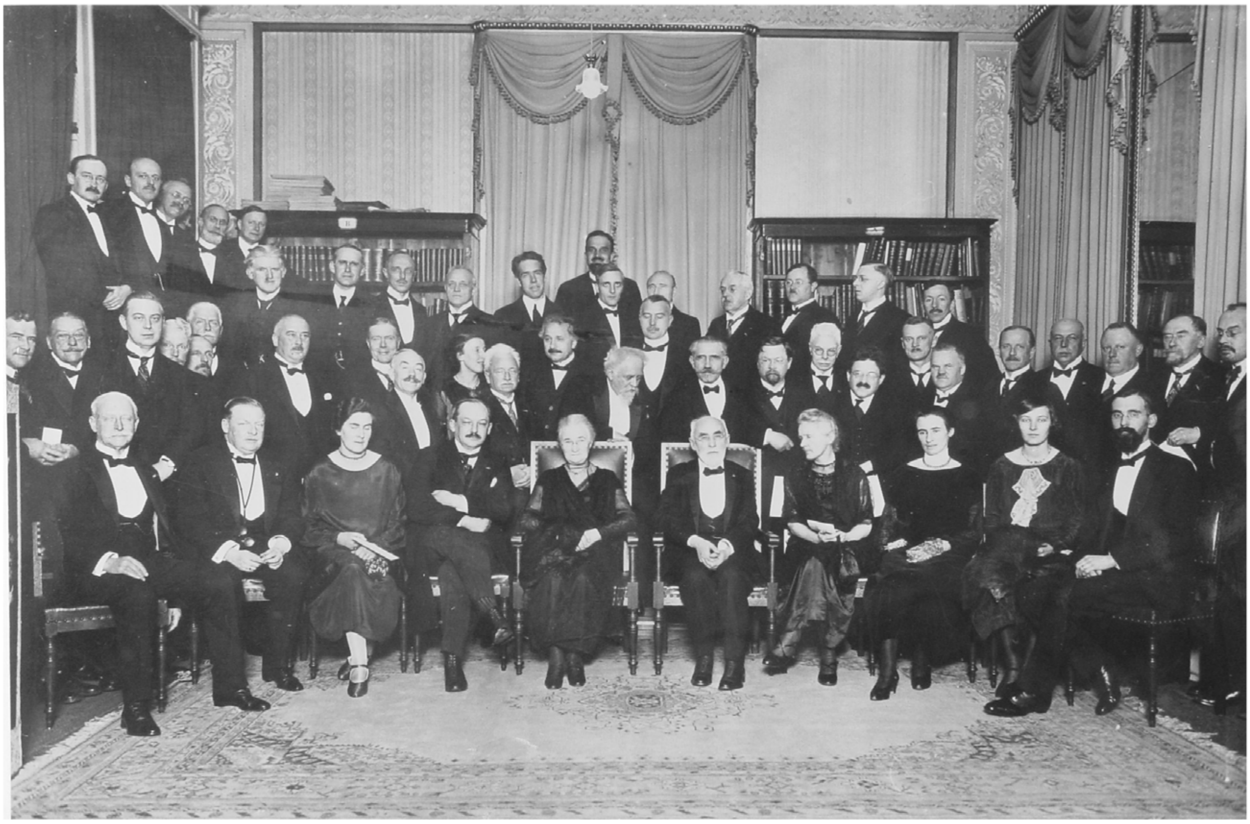

Figure 4. After the celebration in Leiden a dinner for an inner circle took place in the building of the Holland Society of Sciences and Humanities in Haarlem. In the centre are Lorentz and his wife, on the right sits Mme Curie and behind her stand Zeeman and Ehrenfest. Bohr can be seen behind Einstein. The picture originates from the Society's archives. Reproduced with permission.

sun was observed. A total solar eclipse was necessary for this observation, since only then would it be possible to measure a small displacement in the visible positions of stars close to the sun.

In 1919, two British expeditions went on expeditions to perform the necessary measurements, and announced their still preliminary findings at a meeting. The results confirmed Einstein's theory. Einstein did not hear of this directly but in a telegram from Lorentz on 22 September 1919 (figure 3), since relations between scientists from different sides in the First World War were still severely strained. On 21 December 1919, Einstein sounded Lorentz out on the possibility of a special professorial appointment in Leiden. Einstein accepted and delivered his inaugural lecture in 1920.

Figure 5. Lorentz monument in Arnhem.
(This figure is in colour only in the electronic version)

7. A national celebrity

Lorentz had a number of public duties besides his work in science. He was for example chairman of the Zuiderzee Commission, appointed to study the effects of the proposed Afsluitdijk (the 'closing dyke' which would convert the Zuiderzee into an inland lake) on the water levels and currents of the Wadden Sea. Lorentz introduced a new, scientifically based method calculating the required dyke heights. The dykes did in fact turn out to be high enough at the time of the disastrous floods of 1953 elsewhere in the country.

From 1923–28, he was also first a member and then the chairman of the League of Nations International Committee on Intellectual Cooperation. The aims of the committee included the restoration of cordial relations among scientists from all countries, and it may be regarded as a predecessor of Unesco.

These public functions brought Lorentz wider recognition among Dutch society at large. It is more probable, however, that his acceptance as a national celebrity was not complete until the celebration of the 50th anniversary of his doctoral thesis (figure 4). A gathering in the Great Auditorium of Leiden University in 1925 in the presence of many notables, among whom were Prince Hendrik of the Netherlands, Bohr, Marie Curie, Einstein and the Prime Minister Colijn. The last three also delivered speeches, while Kamerlingh Onnes announced the foundation of the Lorentz Fund to promote the practice of theoretical physics by among other means fostering contacts between Dutch and foreign scientists. Donations had been received from two thousand people, one thousand of them from the Netherlands and another thousand from 19 other countries. Kamerlingh Onnes expressed the sum received in guilders: 100 000, at the time a considerable amount of money. This all demonstrated the extent to which Lorentz had become nationally and internationally recognized as a scientist and a personality, and it penetrated to the Dutch public outside the Great Auditorium. The national weekly *De Haagse Post* even published a cartoon about the event.

Just over two years later, Lorentz died following a short illness. The funeral took place in Haarlem and made a considerable impression: the telegraph traffic was silenced for three minutes throughout the Netherlands. Ehrenfest, Rutherford, Langevin and Einstein addressed the mourners, and many thousands of people witnessed the funeral procession.

Not surprisingly, the idea of erecting a monument was soon raised. That happened, however, in three places: Arnhem, Leiden and Haarlem. Holding a competition for a monument was considered inappropriate, so a national committee of one hundred prominent Dutch citizens was formed. The committee appealed for donations to fund a magnificent monument which would be erected in Arnhem (figure 5); Leiden and Haarlem would receive more modest public memorials. The Arnhem monument does justice to Lorentz's outlook on the manifold contributions to the development of physics. He is portrayed centrally, flanked on the monument walls in low relief by predecessors Huygens, Fresnel, Maxwell, whose ideas he brought to completion and successors, Planck, Einstein, Bohr, who would continue the development of physics after him. It is a unique monument, which not only honours Lorentz but also memorializes the past and the future. Of course, after its inauguration in 1931 the monument remained in the state as the sculptor Wenckebach finished it, but physics progressed. However, in 2008 the monument witnessed a revival originating from visual artist van Houwelingen, who suggested the use of the unmarked monument walls to carve names of scientists who are representative for modern physics. For this purpose a committee of physicists made a choice among the names of 20th century Nobel laureates in physics, who represent in a broad sense the thousands of physicists who contributed to modern physics. With this update the monument expresses an ongoing human activity, the pursuit of an understanding of nature, which is an essential part of our culture.

Translated by Victor Joseph