From gunpowder-blast to Nobel Prizes: An explosion in Leiden

Jos J. Eggermont

1. Blast

During the French occupation of what is now the Netherlands, a ship loaded with 17,000 kg of gunpowder on its way from Hilversum to Delft was moored at the *Steenschuur* in Leiden.[1] It exploded on January 12, 1807 at 16:15, for reasons still not known with certainty, albeit rumours abound. The explosion caused the deaths of 151 people and wounded more than 2,000. About 220 houses were completely destroyed or were no longer habitable. Even on the outskirts of the city many windows were destroyed. The sound of the explosion was heard in The Hague, about 15 km away.

King Lodewijk Napoleon was quickly present to view the disaster. On the spot, he donated 30,000 guilders from his private means, and granted the city of Leiden freedom from taxes for 10 years. Little did he know that he would be forced to abdicate as king in 1810, after which the country became part of France. He also organized a national collection for the recovery of the disaster area, which resulted in about two million guilders. His residence in The Hague, *Paleis ten Bosch*, was readied as a hospital. The badly damaged Roman Catholic church near the disaster area was restored and christened the *Lodewijks church* (after the patron saint of the King).

The large hole in the center of Leiden allowed the university to build a large laboratory on the empty spot at the *Steenschuur* that housed the Departments of Anatomy, Chemistry, Physiology and Physics and the university administration. The building was completed around 1860. Across the *Steenschuur* canal a pleasant park was laid out and named after Van der Werff, who was mayor at the time of

[1] This is the text of a presentation delivered to the annual meeting of the Canadian Association for the Advancement of Netherlandic Studies / Association canadienne pour l'avancement des études néerlandaises (CAANS-ACAEN) held at the University of Regina, Regina. Saskatchewan, on May 26-27, 2018.

the liberation of Leiden from the Spanish siege in 1574. (This section is based on Wikipedia Contributors 2017.)

Figure 1. Lodewijk Napoleon visits the victims of the gunpowder ship in Leiden, 1807. Painting by Carel Lodewijk Hansen, 1807, Rijksmuseum Amsterdam, SK-A-3925.

2. Nobel Prizes

The Nobel Prizes form a set of annual international awards in recognition of academic, cultural and/or scientific advances. The Nobel Prize was funded by Alfred Nobel’s personal fortune. In 1888, Nobel was astonished to read his own obituary, entitled “The merchant of death is dead”, in a French newspaper. As it was Alfred's brother Ludvig who had died, the obituary was eight years premature. The article disconcerted Nobel and made him apprehensive about how he would be remembered. According to official sources, Alfred Nobel bequeathed 94% of his fortune to the Nobel Foundation that now forms the economic base of the Nobel Prize. The awards are in Physics, Chemistry, Physiology and Medicine, Literature and Peace. The latter was originally described as “to be given to the person or society that renders the greatest service to the cause of international fraternity, in the suppression or reduction of standing armies, or in the establishment or furtherance of peace congresses" (Chisholm 1911).

The first Nobel Prizes were awarded in 1901; three of the recipients were the Dutchman Jacobus Henricus van 't Hoff (Chemistry, University of Groningen), the German Willem Conrad Röntgen (Physics), and the Swiss Henri Dunant (Peace). The Leiden Nobel Prize explosion led to five awardees of which four in Physics: Lorentz and Zeeman (1902), Van der Waals (1910), Kamerlingh Onnes (1913); and Einthoven (1924) in Physiology and Medicine.

3. The path to the four Nobel Prizes in Physics

3.1 Lorentz and Zeeman

Hendrik Antoon Lorentz was born in Arnhem, the Netherlands, on July 18, 1853, as the son of a plant-nursery owner. When he was four years old, his mother died. In those days the elementary school did not only have school hours in the morning and in the afternoon, but also in the evening. When in 1866 the first high school, HBS (*Hogere Burgerschool*, a type of high school dominated by science courses but without classical languages) opened its doors in Arnhem, Hendrik Lorentz, as a gifted pupil, was ready to be placed in the 3rd year. After the 5th year and a year of study of the classics, required for admission, he entered Leiden University in 1870, obtained his B.Sc. degree in mathematics and physics in 1871, and returned to Arnhem in 1872 to become an evening-school teacher, while at the same time preparing for his doctoral thesis on the reflection and refraction of light. Hendrik Lorentz obtained his doctorate in 1875, when he was just 22 years old; no more than three years later he became professor of theoretical physics at Leiden University, a position especially created for him, and 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 he proved an ideal colleague for him (Berends 2009).

Pieter Zeeman was born on May 25, 1865, at Zonnemaire, a small village on Schouwen-Duiveland, Zeeland, as the son of the local clergyman. After having finished his high school education at Zierikzee, he went to Delft for two years to be tutored in the classical languages, which was required for admission to the university. In Delft, he stayed at the home of Dr. J.W. Lely, brother of Cornelis Lely, who was responsible for the concept and realization of the *Zuiderzee* Works. This was an early connection to Lorentz' post-retirement work (see below). In 1883, the aurora borealis happened to be visible in the Netherlands. Zeeman, then a student at the high school in Zierikzee, made a drawing and description of the phenomenon and submitted it to the journal *Nature*, where it was published. The editor praised "the careful observations of Professor Zeeman from his observatory in Zonnemaire." In 1893 he submitted his doctoral thesis on the Kerr effect, prepared under the supervision of Kamerlingh Onnes, to Leiden University and became a *Privatdozent*. Pieter Zeeman's time at Leiden University during that period took an unexpected turn in the year 1896, when he was fired by Kamerlingh Onnes, because he conducted experiments in the laboratory in relation to spectral lines in a direct violation of orders. His research on spectral lines nevertheless became the bedrock of his career as a scientist. In that same year, Zeeman presented his findings at the Royal Netherlands Academy of Arts and Sciences and in the Proceedings of the Royal Society of London, and was immediately recognized by eminent scientists. His old mentor Hendrik Lorentz also took an interest in the findings and consequently it became well known (Van der Waals Jr 1943-1944).

In 1902, Pieter Zeeman received the Nobel Prize in Physics together with Lorentz "in recognition of the extraordinary service they rendered by their researches into the influence of magnetism upon radiation phenomena" (Nobel media n.d.-f). In 1908 Pieter Zeeman was made director of the Institute of Physics in Amsterdam and became the successor of Van der Waals.

Having obtained national as well as international celebrity status, Hendrik Lorentz was appointed in 1919 as chairman of the committee whose task it was to study the movements of seawater, which could be expected during and after the reclamation of the *Zuiderzee*, now called *IJselmeer*, in the Netherlands. This was one of the greatest works of all time in hydraulic engineering and was potentially only matched by the Delta Works initiated after the 1953 flood disaster. Lorentz was 65 when he took on this assignment. He had retired from Leiden University a few years earlier and had moved to Haarlem, but he still came to Leiden each Monday to lecture on fundamental topics in physics. His theoretical calculations on water movements, the result of eight years of pioneering work, have been confirmed in actual practice in the most striking manner, and have ever been of permanent value to the science of hydraulics (Berends 2009). (This section is partially based on Nobel Media n.d.-a; b.)

3.2 Van der Waals

The third Nobel Prize in Physics went to Johannes Diderik van der Waals in 1910, for his work on "the equation of state for gases and liquids." This was based on his doctoral dissertation of the same title based on work he did in the Leiden Physics Laboratory. Johannes Diderik van der Waals was born on November 23, 1837 in Leiden, the Netherlands. After having finished his education at his place of birth, he became a schoolteacher. Although he had no knowledge of classical languages, and thus was not allowed to take academic examinations, he continued studying at the university in his spare time during the years 1862-1865. In this way he obtained teaching certificates in mathematics and physics. In 1864 he was appointed teacher at a high school at Deventer; in 1866 he moved to The Hague, first as a teacher and later as director of one of the high schools in that town. In his doctoral dissertation (1873, i.e., two years before Lorentz) he put forward an "Equation of State", embracing both the gaseous and the liquid state; he could demonstrate that these two states of aggregation not only merge into each other in a continuous manner, but that they are in fact of the same nature. This put him in the foremost rank of world physics. Valderrama (2010) notes that in his marvellous Nobel lecture, Van der Waals addressed a strong and clear speech to those who, without foundation, opposed his ideas: "It will be perfectly clear that in all my studies I was quite convinced of the real existence of molecules, that I never regarded them as a figment of my imagination [...] When I began my studies I had the feeling that I was almost alone in holding that view. Many of those who opposed it most have ultimately been won over, and my theory may have been a contributory factor." (This section is partially based on Nobel Media n.d.-c.)

3.3 Kamerlingh Onnes

Heike Kamerlingh Onnes was born on September 21, 1853, in Groningen, The Netherlands, where his father owned a brickworks factory. After spending the allotted time at the HBS in his native town, he received supplementary teaching in Greek and Latin. Kamerlingh Onnes became head of experimental physics (residing in part of the Laboratory built on the 'Ruin'). In his inaugural address "*De beteekenis van het quantitatief onderzoek in de natuurkunde*" ('The importance of quantitative research in physics') he arrived at his well-known motto "*Door meten tot weten*" ('Knowledge through measurement'), an appreciation of the value of experiments, which concerned him throughout his scientific career. Another momentous discovery (1911) was that of the superconductivity of pure metals such as mercury, tin and lead at very low temperatures. (This section is partially based on Nobel Media n.d.-d.)

3.4 The evolution of the Leiden physics laboratory

Kamerlingh Onnes' research program was based on investigating the work of Van der Waals for substances that "boiled" at very low temperature, such as helium, as well as their magnetic, optical, and electric properties. Liquid helium was produced for the first time in 1908, and later Kamerlingh Onnes managed to reach a temperature of less than one degree above the absolute minimum, which is at –273˚ Celsius. In 1913, he received the Nobel Prize in physics "for investigations on the properties of matter at low temperatures which let inter alia, to the production of liquid helium". Kamerlingh Onnes was a very able manager, who needed lots of laboratory space. He gradually pushed his chemistry, anatomy and physiology colleagues out of the building and the central administration also left. The Leiden physics laboratory was considered the leading one in the country, and under Kamerlingh Onnes it soon established an international reputation too. However, in 1896, the town council panicked upon learning that, in the laboratory on the 'Ruin', Kamerlingh Onnes was working with considerable quantities of compressed hydrogen gas. This resulted in a prohibition on the storing of hydrogen and some of the laboratory's essential lines of research had to be closed down for several months. After regular checks and a no-smoking regulation were introduced, Kamerlingh Onnes and his staff were again permitted to resume their hydrogen work (Gorter & Taconis 1964). Maybe this stressful time for Kamerlingh Onnes caused his firing of Zeeman in 1896. Part of the problems that continued after 1900 also resulted from the less than harmonious relationship between Kamerlingh Onnes and the physiologist Einthoven, who complained continuously about vibrations caused by the vacuum pumps in the physics laboratory, which disturbed Einthoven's measurements with his newly invented and very sensitive recording equipment (Gorter & Taconis 1964).

Figure 2. The Kamerlingh Onnes Laboratory in 1926. Postcard in author's personal collection.

In 1920, the laboratory at the *Steenschuur* was expanded to about twice its original (~1860) size. The front view as it was in 1920 is still the same at the time of this writing, albeit that the building now houses the Law Faculty, as physics together with most experimental university departments moved to the new research space between Leiden and Rijnsburg. In 1932 the laboratory was named the Kamerlingh Onnes laboratory. Kamerlingh Onnes ruled his new empire as an enlightened dictator. This is what one can deduce from experiences and opinions of contemporary physicists in Leiden (Casimir 1992).

Hendrik Casimir (1909-2000) merged the two cultures of science and technology in the course of his career. After being trained in theoretical physics by the founding fathers of quantum mechanics (Bohr, Pauli, Ehrenfest), he himself made fundamental scientific contributions as a professor in Leiden and as a director of the Philips Research Laboratory in Eindhoven.

> As the director of an enterprise, Kamerlingh Onnes also set up a well-oiled organization presided over by an administrative supervisor, a research team including assistants and postgraduate students, a manager, instrument-makers, glass-blowers, laboratory assistants, technicians, an engineer, an assistant supervisor, not to mention a small army of trainee instrument-makers to perform any number of odd jobs. HKO's project was, indeed, Big Science. (Van Delft 2011, 14)

One of the consequences of the Big Science was that Kamerling Onnes needed extensive cryogenic equipment, required for his low-temperature studies, to be constructed in-house. For that purpose, he had already founded the "*Leiden Instrument-makers en Glasblazers School*" ('Leiden instrument maker and glass blowers school') as early as 1901. The graduates are excellent and world-renowned. The school has expanded over the years and currently has between 300 and 400 students in its 4-year curriculum. Experimental physics students entering the post-bachelor phase also had to participate in a school practicum for three weeks, just to get an idea of how difficult precision instrument making is, and to prepare them for well thought-out requests for equipment needed in their research. I had the 'privilege' to also undergo this ritual, at the start of the years leading up to the Dutch equivalent of the M.Sc. degree. I was given a lump of metal and told to make a perfect cube out of it.

3.5 World recognition of Leiden physics

International recognition was reflected in a *Scientific American* paper stating:

> The most remarkable plant for the continuous production of low temperatures is that of the laboratory directed by M. Kamerlingh Onnes, professor at the University of Leiden. This installation has required on the part of this learned physicist more than twenty-five years' of persevering

> efforts such as only those who have in some sort personally conducted research work can comprehend. (Bresch 1912, 93)

During his early and middle career years, Albert Einstein often spent time (starting in 1911) at Leiden University visiting Lorentz. Later (from 1914 on) he often visited his friend Ehrenfest who in 1914 had succeeded Lorentz as professor in theoretical physics at Leiden.

Einstein and Ehrenfest were soul mates. They first met in February 1912 in Prague, where Einstein was a professor until he moved to Zürich later that year. The friendship clicked from the very beginning. They interrupted their intense discussions on subjects like the ergodic principle or gravitation to play Brahms sonatas, with Einstein on the violin and Ehrenfest at the piano (Van Delft 2006, 57).

In 1920, Einstein also visited Pieter Zeeman in Amsterdam where the latter had been appointed Professor in experimental physics shortly after receiving the Nobel Prize.

4. Nobel Prize in Physiology

Willem Einthoven was born on May 21, 1860, in Semarang on the island of Java, in the former Dutch East Indies (now Indonesia). His father was an army medical officer in the Indies, and later became parish doctor in Semarang. His mother was the daughter of the then director of Finance in the Indies. Willem was the eldest son, and the third child in a family of three daughters and three sons. At the age of six, Einthoven lost his father. Four years later his mother decided to return with her six children to Holland, where the family settled in Utrecht.

After the HBS – note that four out of five Leiden Nobel laureates received their secondary education at a HBS – Einthoven worked in close association with the great physiologist F.C. Donders, under whose guidance he undertook a study, which was published in 1885 as his doctoral dissertation: *Stereoscopie door kleurverschil* ('Stereoscopy by means of colour variation'), a method that is still applied today in movie theaters by distributing glasses – one red colored and one green – to induce a virtual 3D image. One of Einthoven's teachers was the physicist C.H.D. Buys Ballot, who discovered the well-known law in meteorology that states: "In the Northern Hemisphere, if a person stands with his back to the wind, the atmospheric pressure is low to the left and high to the right" (Wikipedia Contributors 2018). That same year, 1885, Einthoven was appointed Professor of Physiology at Leiden University with his laboratory space in the same building as Kamerlingh Onnes.

The string galvanometer, which he subsequently developed (Einthoven 1903), has led countless investigators to study the functions and diseases of the heart muscle. The string galvanometer consisted of a several meters long, very thin silver-coated quartz string that conducted the electrical currents from the heart. This string was placed in a powerful magnetic field, which caused sideways displacement of the string in proportion to the current carried. The movement in the filament was projected through a thin slot onto a moving photographic plate. The original machine required water-cooling for the powerful electromagnets and weighed some 600 lbs (Barold 2003).

Einthoven received the Nobel Prize in Medicine in 1924 "for his discovery of the mechanism of the electrocardiogram". The Physiology laboratory at Leiden, then separate from the Kamerlingh Onnes laboratory, became a place visited by scientists from all over the world. (This section is partially based on Nobel Media n.d.-e.)

5. Is there a causal link between the gunpowder blast and the five Nobel Prizes?

The Netherlands received a total of 20 personal Nobel Prizes between 1901 and 2017. In the first 25 years (1901-1926) there were the five from Leiden plus Van 't Hoff (Groningen, 1901) and Tobias Asser (1911), who studied law at Leiden University and was a law professor at the University of Amsterdam, for Peace. In the next 25 years there were two, then from 1951 to 1976 four, and between 1976 and 2017 there were seven. The number in the first 25 years was, for the Netherlands, disproportionately large and the recipients were largely from the Leiden University laboratory erected on the 'Ruin' left by the gunpowder blast. I credit the success to both Hendrik Lorentz and Johannes van der Waals, who instilled an interest and experience in the new field of theoretical physics, and the relentless drive and mastery of experimental physics of Heike Kamerlingh Onnes, which not only contributed to the training in both fields of Pieter Zeeman, but also acted as a stimulant for the strongly physics-oriented Willem Einthoven, albeit that their personal relationship was strained. The proximity of all these people in the same physical space provided by the gunpowder blast contributed, in my opinion, in no small part to the resulting excellence and productivity.

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