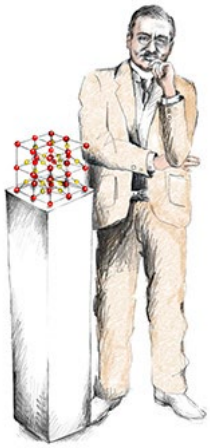
University of Zurich[UZH]

Peter Debye

Nobel Prize in Chemistry 1936



Nobel Prize in Chemistry 1936 "for his contributions to our knowledge of molecular structures through his investigations on dipole moments and the diffraction of X-rays and electrons in gases"

* 24 March 1884 in Maastricht

† 2 November 1966 in Ithaca, NY

1911–1912 Professor for Theoretical Physics at the University of Zurich

The Leonardo of Physics

April 1914: The University of Zurich celebrates the opening of its new university building, whose impressive tower now overtops the neighboring ETH building. In honor of the occasion, the Zurich guilds dedicate "Sechseläuten," their traditional spring procession, to the history of knowledge. The city is festively flagged. The guests, from home and abroad, include the Dutch physicist Peter Debye. With his wife, he is the guest of Alfred Kleiner, the head of the Physics Institute. There is plenty to talk about: For three semesters, from spring 1911 to summer 1912, Debye, as Albert Einstein's successor, occupied the Chair for Theoretical Physics at the University, first as associate professor, then as full professor. And the University still hopes to entice its professor to return. But Debye knows what he's worth. Negotiations prove difficult and in 1915 are broken off altogether. Nobody then has any idea that a couple of years later Debye will return to join the "competition" at ETH.

The first time he came to Zurich, Peter Debye was 26, and the associate professorship at the University was his first teaching appointment. He had been recommended for this first academic position by the physicist Arnold Sommerfeld, who had become aware of the young man's talents in Aachen, where Debye studied. When Sommerfeld went to Munich, Debye became his assistant. Wilhelm Conrad Röntgen, who was also teaching in Munich, gave him an excellent reference: For the University of Zurich, Debye represented "an excellent acquisition."

On a postcard depicting Zurich and the Alps, in 1911 Peter Debye offered Sommerfeld his first impressions. He was looking for accommodation, "a very boring business." Alfred Kleiner, under whom he worked, was "very nice," but there was "something a bit imperial about him with regard to his institute." At his first meeting with his students, the young lecturer was able "with some difficulty, finally to agree a time for his lectures." Debye ended his brief report with praise for the city of Zurich: "Zurich itself is charming; the sunset this evening was truly wonderful."

In Munich, Professor Sommerfeld and his wife had taken on something of a parental role for Debye. His actual parents were distanced from academic life. Sommerfeld once described Debye as his greatest discovery in physics, and the young researcher's outstanding talent quickly became obvious in Zurich. On 10 December 1911, Debye wrote to Sommerfeld in Munich: "Dear Sommerfeld, In the last 48 hours I have discovered something really special." This "something special" was to occupy Debye for 40 years, and also become the basis for his Nobel Prize in 1936. It was the idea that there are molecules that are permanent electrical dipoles. The "dipole moment" of a substance can be measured, and enables conclusions as to its molecular structure. The brief period of Debye's activity at the University saw more fundamental work based on the hypothesis of permanent dipoles, for example, on the behavior of molecules when temperature changes.

"Debye is an excellent acquisition for the University of Zurich."

Wilhelm Conrad Röntgen

Debye was not only a brilliant researcher, he was also a good teacher. His lectures and experiments – in those days part of the job specification for a theoretical physicist – were always perfectly prepared and his humorous style enabled him to communicate complicated content with apparent ease, making him much loved as a teacher. He himself seemed to possess unlimited powers of scholarly comprehension, and became known for his frequent remark of "But it's really quite simple!"

Barely a year after his arrival in Zurich, Peter Debye reported to his mentor in Munich that "after much internal struggle" he had accepted an appointment at the University of Utrecht. Kleiner, the head of the institute, wrote to Sommerfeld that he greatly regretted the departure of his "dear colleague Debye," who had "become our pride and joy." His students tried in vain to change his mind with a torchlight procession. Debye set out the reasons for his decision in detail in his letter to Sommerfeld, including criticisms of the situation in Zurich. He had endeavored to ensure that "the large salary offered by the University of Utrecht did not cloud my judgment." Other reasons weighed more heavily: "I saw that in Zurich I would undoubtedly have to sacrifice years to get a laboratory more or less in order … in Utrecht, I am not obliged to worry about experiments; I will not need to ensure, day by day and as tactfully as possible, that people do not try to base their work on outdated, impossible ideas."

Debye's hope that a successor for his professorship in Zurich could be found by the beginning of the summer semester 1912 was not fulfilled. Max von Laue, a student of Sommerfeld's whom Debye had first proposed, accepted Zurich's offer, but then began to make additional demands, which delayed his appointment. This seriously annoyed Debye, who was forced to come to the assistance of "good old Kleiner" and remain in Zurich for the summer semester.

In addition to the "tiresome Laue business," there was another topic in the spring of 1912 that stirred Peter Debye's emotions. On this subject, he preferred to write, somewhat bashfully, to Sommerfeld's wife. This particular affair of the heart concerned Mathilde Alberer, the daughter of his previous landlord in Munich. It had not escaped the notice of his colleague in Zurich. "Debye is currently living in seventh heaven," Kleiner reported to Sommerfeld. The latter now offered his previous pupil the paternal "Du" form of address. The 28-year-old professor was soon engaged to Hilde, though she was still at a boarding school in Les Brenets in the Canton of Neuchâtel. They were married in Munich, on 10 April 1913.

"But it's really quite simple!" – Peter Debye's powers of scholarly comprehension seemed limitless.

As the position in Utrecht did not come up to Debye's expectations, in the fall of 1914 he accepted a professorship in Göttingen, where he remained throughout the First World War. As a Dutch national, he was not conscripted and was able to continue researching, if with limited resources. However, the precarious conditions in postwar Germany moved him to consider applying for the vacant Chair of Physics at ETH. After a tussle over his salary, in 1920 he returned to Zurich. In the end, he was given several special allowances, including "period of service credited from 1911." This time he would stay in Zurich for seven years.

Debye's two periods in Zurich were very different. At the University, he was a new and inexperienced associate professor. He came to ETH already famous as a physicist, and had to take on numerous duties as head of department. He was also a father: His son, Peter Paul, born in 1916, was joined, in Zurich, by his daughter Mathilde Maria in 1921. As a University professor, Debye had lived at Bolleystrasse 50; now, the family lived first in a new building at Walchestrasse 19, but then moved to Zürichbergstrasse 4.

Despite his many duties, Debye was able, together with his assistant, Erich Hückel, whom he had brought with him from Göttingen, to publish important work in physics. On his recommendation, another Göttingen colleague, Paul Scherrer from St. Gallen, joined ETH as professor for physics. In 1915 they had jointly developed the Debye-Scherrer method, an experimental method for determining the structure of pulverized crystals using X-rays. Scherrer remained in Zurich till he retired, and, together with Debye's successor, Wolfgang Pauli, would shape the course of physics in Zurich for decades to come.

In 1927 Debye was offered an appointment in Leipzig at such attractive conditions that ETH neither could, nor would, match them. Debye rapidly made the Leipzig Institute one of the leading addresses for physics. In 1933, for the second time after Zurich, he had the opportunity to take over a chair previously occupied by Einstein, who resigned for political reasons from his position as director of the Kaiser-Wilhelm-Institut

für Physik in Berlin. The award of the Nobel Prize in Chemistry in 1936 further enhanced Debye's reputation: He served Germany's new rulers as a symbol of the quality of German science.

When, however, in the fall of 1939 the authorities demanded that he either renounce his Dutch citizenship or retire, Debye saw himself forced to act. He took leave in order to accept a visiting professorship at Cornell University in Ithaca, traveled to the USA in January 1940 – and remained there for the rest of his life. But when, after the war, he returned to Europe to lecture, Debye filled the auditoriums, not least in Zurich. "With his unshakeable temperament, he knew how to present a problem with unsurpassable clarity and solve it with astonishing elegance," Alfred Brunner wrote in his obituary in the NZZ. *Margrit Wyder*

Peter Debye developed an experimental method for determining the structure of pulverised crystals.

Source: Margrit Wyder: *Einstein und Co. – Nobelpreisträger in Zürich;* Verlag NZZ libro, Zürich 2015 **Illustration:** Aline Telek
Translation: University of Zurich

Calculated in Zurich:

The Forms of Molecules

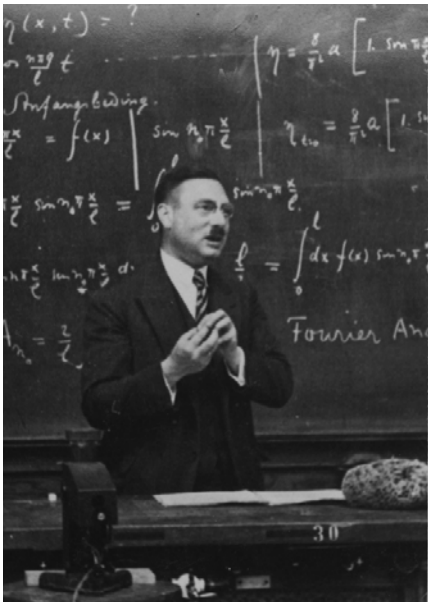
Peter Debye was described by his colleagues at Cornell University as the "Leonardo Da Vinci" of the 20th century. Many methods and laws in physics bear his name. The "Debye temperature," for example, comes from his theory concerning the specific heat of solid bodies, which he developed at the University of Zurich. "Debye" also became the name of the unit for the electric dipole moment. The discovery and measuring of the dipole moment was mentioned explicitly in the motivation for his Nobel Prize, and was also the reason why, as a physicist, he was awarded the Chemistry Prize. For chemists, this represented a new and important possibility for determining the structure of molecules. Debye had first concerned himself with the subject in 1911, during his time as professor at the University of Zurich.

Whether a molecule has a dipole moment depends on its form. Thus, a water molecule, with the chemical formula H_2O, is an electric dipole; the gas CO_2, on the other hand, not. Why is this? In CO_2 the two oxygen atoms and the carbon atom to which they are linked are in a straight line. This neutralizes their charges. With the water molecule, by contrast, the two hydrogen atoms linked to the oxygen atom form an angle, so that the charges do not cancel out and an electric field is generated that can be measured. Conversely, the measurement of this dipole moment enables conclusions about the spatial structure of a molecule. Debye was able to conduct such measurements during his second period in Zurich, as professor at ETH. He was, for example, able to calculate that the ammonia molecule with the formula NH3 must have a pyramidal form, as shown in his illustration.

A further reason for the award of the Chemistry Prize to Debye was his work with gases. After Max von Laue's discovery, in 1912, of the diffraction of X-rays on crystals, Debye was able to extend this method to crystalline powder, to liquids, and ultimately, in 1928, to gases. He undertook these investigations in Göttingen, with the Swiss Paul Scherrer. They also achieved similar diffractions with electron beams, though this method above all offers insights into atomic nuclei.

Did Debye perhaps inspire the work behind Erwin Schrödinger's 1933 Nobel Prize in Physics? Felix Bloch, Nobel Physics laureate in 1952, as a student attended a colloquium led jointly by Debye and his University colleague, Schrödinger. According to Bloch, in 1926 Schrödinger, inspired by Debye, talked about waves; Debye said that waves required the establishment of a wave equation – and a few weeks later, Schrödinger presented exactly that. *(MW)*

Peter and Hilde Debye on Lake Zurich in 1926. Photo: Courtesy Ava Helen and Linus Pauling Papers, Oregon State University Libraries



Peter Debye as a young instructor.
Photo: ETH Library Zurich, archives