Lise Meitner

Lise Meitner (English: /ˈliːzə ˈmaɪtnər/; 7 November 1878 – 27 October 1968) was an Austrian-Swedish physicist who worked on radioactivity and nuclear physics. Meitner and Otto Hahn led the small group of scientists who first discovered nuclear fission of uranium when it absorbed an extra neutron; the results were published in early 1939.[4][5] Meitner and Otto Frisch understood that the fission process, which splits the atomic nucleus of uranium into two smaller nuclei, must be accompanied by an enormous release of energy. Nuclear fission is the process exploited by nuclear reactors to generate heat and, subsequently, electricity.[6] This process is also the basis of the nuclear weapons that were developed in the U.S. during World War II and used against Japan in 1945.

Meitner spent most of her scientific career in Berlin, Germany, where she was a physics professor and a department head at the Kaiser Wilhelm Institute; she was the first woman to become a full professor of physics in Germany. She lost these positions in the 1930s because of the anti-Jewish Nuremberg Laws of Nazi Germany, and in 1938 she fled to Sweden, where she lived for many years, ultimately becoming a Swedish citizen.

Meitner received many awards and honors late in her life, but she did not share in the 1944 Nobel Prize in Chemistry for nuclear fission that was awarded exclusively to her long-time collaborator Otto Hahn. In the 1990s, the records of the committee that decided on that prize were opened. Based on this information, several scientists and journalists have called her exclusion "unjust", and Meitner has received a flurry of posthumous honors, including naming chemical element 109 meitnerium in 1992.[7][8][9][10][11][12][13] Despite not having been awarded the Nobel Prize, Lise Meitner was invited to attend the Lindau Nobel Laureate Meetings in 1962.[14]

Lise Meitner

Lise Meitner in 1946

Born	7 November 1878[1][2] Vienna, Austria-Hungary
Died	27 October 1968 (aged 89) Cambridge, England
Residence	Austria, Germany, Sweden, United Kingdom
Citizenship	Austria (pre-1949), Sweden (post-1949)
Alma mater	University of Vienna
Known for	Nuclear fission
Awards	Lieben Prize (1925) Max Planck Medal (1949) Otto Hahn Prize (1955) ForMemRS (1955)[3]

Contents

Early years

Meitner in 1906

She was born **Elise Meitner** on 7 November 1878 into a Jewish upper-middle-class family in Vienna, 2nd district (Leopoldstadt), the third of eight children. Her father Philipp Meitner[15] was one of the first Jewish lawyers in Austria.[12] She shortened her name from Elise to Lise.[16] The birth register of Vienna's Jewish community lists Meitner as being born on 17 November 1878, but all other documents list her date of birth as 7 November, which is what she used.[1] As an adult, she converted to Christianity, following Lutheranism,[1][17] and was baptized in 1908.[18]

	Wilhelm Exner Medal (1960) Enrico Fermi Award (1966)
Scientific career	
Fields	Physics
Institutions	Kaiser Wilhelm Institute University of Berlin, Manne Siegbahn Laboratory University College of Stockholm
Doctoral advisor	Franz S. Exner
Other academic advisors	Ludwig Boltzmann Max Planck
Doctoral students	Arnold Flammersfeld Kan-Chang Wang Nikolaus Riehl
Other notable students	Max Delbrück Hans Hellmann
Influenced	Otto Hahn
Signature	
	

Education

Meitner's earliest research began at age 8, when she kept a notebook of her records underneath her pillow. She was particularly drawn to math and science, and first studied colors of an oil slick, thin films, and reflected light. Women were not allowed to attend public institutions of higher education in Vienna around 1900, but Meitner was able to achieve a private education in physics in part because of her supportive parents, and she completed in 1901 with an "externe *Matura*" examination at the Akademisches Gymnasium.[3][19]

Meitner studied physics and went on to become the second woman to obtain a doctoral degree in physics at the University of Vienna in 1905 (her dissertation was on "heat conduction in an inhomogeneous body").[12] While at the University, she took her studies very seriously. Because she was unsure if she wanted to study mathematics or physics, she attended multiple lectures in both areas of study, "taking more notes than the registered students".

While studying a beam of alpha particles, she found that scattering increased with the atomic mass of the metal atoms, in her experiments with Collimators and metal foil, which led Ernest Rutherford later on to the nuclear atom, and which had been her forte, submitting her report of same to the Physikalische Zeitschrift on 29 June 1907.[20]

After she received her doctorate, Meitner rejected an offer to work in a gas lamp factory. Encouraged by her father and backed by his financial support, she went to the Friedrich-Wilhelms-Universität in Berlin where famous physicist Max Planck allowed her to attend his lectures, an unusual gesture by Planck, who until then had rejected any woman wanting to attend his lectures.[21][22]

Scientific career

After one year of attending Planck's lectures, Meitner became Planck's assistant. During the first years she worked together with chemist Otto Hahn and together with him discovered several new isotopes. In 1909 she presented two papers on beta-radiation. She also, together with Otto Hahn, discovered and developed a physical separation method known as radioactive recoil, in which a daughter nucleus is forcefully ejected from its matrix as it recoils at the moment of decay

In 1912 the research group Hahn–Meitner moved to the newly founded Kaiser-Wilhelm-Institute (KWI) in Berlin-Dahlem, south west in Berlin. She worked without salary as a "guest" in Hahn's department of Radiochemistry. It was not until 1913, at 35 years old and following an offer to go to Prague as associate professor, that she got a permanent position at KWI.

In the first part of World War I, she served as a nurse handling X-ray equipment. She returned to Berlin and her research in 1916, but not without inner struggle. She felt in a way ashamed of wanting to continue her research efforts when thinking about the pain and suffering of the victims of war and their medical and emotional needs.[23]

Lise Meitner and Otto Hahn in their laboratory

In 1917, she and Hahn discovered the first long-lived isotope of the element protactinium, for which she was awarded the Leibniz Medal by the Berlin Academy of Sciences. That year, Meitner was given her own physics section at the Kaiser Wilhelm Institute for Chemistry.[12]

In 1922, she discovered the cause of the emission from surfaces of electrons with 'signature' energies, known as the Auger effect.[24] The effect is named for Pierre Victor Auger, a French scientist who independently discovered the effect in 1923.[25][26]

In 1926, Meitner became the first woman in Germany to assume a post of full professor in physics, at the University of Berlin. In 1935, as head of the physics department of the Kaiser Wilhelm Institute for Chemistry in Berlin-Dahlem (today the Hahn-Meitner Building of the Free University) she and Otto Hahn, the director of the KWI, undertook the so-called "transuranium research" program. This program eventually led to the unexpected discovery of nuclear fission of heavy nuclei in December 1938, half a year after she had left Berlin. She was praised by Albert Einstein as the "German Marie Curie".[12][27][28]

While at the Kaiser Wilhelm Institute, Meitner corresponded with James Chadwick at the Cavendish Laboratory at Cambridge. As Chadwick and others were attempting to prove the existence of the neutron, Meitner sent Polonium to Chadwick for his experiments. Chadwick eventually required and received more polonium for his experiments from a hospital in Baltimore, but he would remain grateful to Meitner.[29] Later, he said he was "quite convinced that [Meitner] would have discovered the neutron if it had been firmly in her mind, if she had had the advantage of, say, living in the Cavendish for years, as I had done."[30]

In 1930, Meitner taught a seminar on nuclear physics and chemistry with Leó Szilárd. After the discovery of the neutron in the early 1930s, the scientific community speculated that it might be possible to create elements heavier than uranium (atomic number 92) in the laboratory. A scientific race began between the teams of Ernest Rutherford in Britain, Irène Joliot-Curie in France, Enrico Fermi in Italy, and Meitner and Hahn in Berlin. At the time, all concerned believed that this was abstract research for the probable honour of a Nobel prize. None suspected that this research would culminate in nuclear weapons.

When Adolf Hitler came to power in 1933, Meitner was still acting as head of the physics department of the Kaiser Wilhelm Institute for Chemistry. Although she was protected by her Austrian citizenship, all other Jewish scientists, including Szilárd, Fritz Haber, her nephew Otto Frisch, and many other eminent figures, were dismissed or forced to resign from their posts. Most of them emigrated from Germany. Her response was to say nothing and bury herself in her work. After the Anschluss in March 1938, her situation became difficult. On July 13, 1938, Meitner, with the support of Otto Hahn and the help from the Dutch physicists Dirk Coster and Adriaan Fokker, departed for the Netherlands. She was forced to travel under cover to the Dutch border, where Coster persuaded German immigration officers that she had permission to travel to the Netherlands. She reached safety, though without her possessions.[31] Meitner later said that she left Germany forever with 10 marks in her purse. Before she left, Otto Hahn had given her a diamond ring he had inherited from his mother: this was to be used to bribe the frontier guards if required. It was not required, and Meitner's nephew's wife later wore it.

An appointment at the University of Groningen did not come through, and with the help of Eva von Bahr and Carl Wilhelm Oseen she went instead to Stockholm, where she took up a post at Manne Siegbahn's laboratory, despite the difficulty caused by Siegbahn's prejudice against women in science. Here she established a working relationship with Niels Bohr, who travelled regularly between Copenhagen and Stockholm. She continued to correspond with Hahn and other German scientists.[32]

Nuclear fission

On occasion of a lecture by Hahn in Niels Bohr's Institute he, Bohr, Meitner and Frisch met in Copenhagen on November 10, 1938. Later they continued to exchange a series of letters. In December Hahn and his assistant Fritz Strassmann performed the difficult experiments which isolated the evidence for nuclear fission at their laboratory in Berlin-Dahlem. The surviving correspondence shows that Hahn recognized that 'fission' was the only explanation for the proof of barium (at first he named the process a 'bursting' of the uranium), but, baffled by this remarkable conclusion, he wrote to Meitner. The possibility that uranium nuclei might break up under neutron bombardment had been suggested years before, notably by Ida Noddack in 1934. However, by employing the existing "liquid-drop" model of the nucleus,[33] Meitner and Frisch, exclusively informed by Hahn in advance, were therefore the first to articulate a theory of how the nucleus of an atom could be split into smaller parts: uranium nuclei had split to form barium and krypton, accompanied by the ejection of several neutrons and a large amount of energy (the latter two products accounting for the loss in mass). She and Frisch had discovered the reason that no stable elements beyond uranium (in atomic number) existed naturally; the electrical repulsion of so many protons overcame the strong nuclear force.[33] They also first realized that Einstein's famous equation, $E = mc^2$, explained the source of the tremendous releases of energy in nuclear fission, by the conversion of rest mass into kinetic energy, popularly described as the conversion of mass into energy. Ironically, Meitner was motivated to begin these calculations in order to show that Irene Joliot-Curie's interpretation of some experiments violated the liquid drop model.

A letter from Bohr had sparked the above inspiration in December 1938: he commented on the fact that the amount of energy released when he bombarded uranium atoms was far larger than had been predicted by calculations based on a non-fissile core. But Meitner and Frisch later confirmed that chemistry had been solely responsible for the discovery, although Hahn, as a chemist, was reluctant to explain the fission process in correct physical terms.

Nuclear fission experimental setup, reconstructed at the Deutsches Museum, Munich

In a later appreciation Lise Meitner wrote:[34]

> The discovery of nuclear fission by Otto Hahn and Fritz Strassmann opened up a new era in human history. It seems to me that what makes the science behind this discovery so remarkable is that it was achieved by purely chemical means.

And in an interview with the West German television (ARD, March 8, 1959) Meitner said:[35]

> Otto Hahn and Fritz Strassmann were able to do this by exceptionally good chemistry, fantastically good chemistry, which was way ahead of what any one else was capable of at that time. The Americans learned to do it later. But at that time, Hahn and Strassmann were really the only ones who could do it. And that was because they were such good chemists. Somehow they really succeeded in using chemistry to demonstrate and prove a physical process.

Fritz Strassmann responded in the same interview with this clarification:[35]

> Professor Meitner stated that the success could be attributed to chemistry. I have to make a slight correction. Chemistry merely isolated the individual substances, it did not precisely identify them. It took Professor Hahn's method to do this. This is where his achievement lies.

Hahn and Strassmann had sent the manuscript of their first paper to *Naturwissenschaften* in December 1938, reporting they had detected and identified the element barium after bombarding uranium with neutrons;[36] simultaneously, Hahn had communicated their results exclusively to Meitner in several letters, and did not inform the physicists in his own institute.

In their second publication on the evidence of barium (*Die Naturwissenschaften*, 10 February 1939) Hahn and Strassmann used for the first time the name *Uranspaltung* (uranium fission) and predicted the existence and liberation of additional neutrons during the fission process (which was proved later to be a chain reaction by Frédéric Joliot and his team). Meitner and Frisch were the first who

correctly interpreted Hahn's and Strassmann's results as being nuclear fission, a term coined by Frisch, and published their paper in *Nature*.[4] Frisch confirmed this experimentally on 13 January 1939.[5]

These three reports, the first Hahn-Strassmann publication of January 6, 1939, the second Hahn-Strassmann publication of February 10, 1939, and the Frisch-Meitner publication of February 11, 1939, had electrifying effects on the scientific community. Because there was a possibility that fission could be used as a weapon, and since the knowledge was in German hands, Szilárd, Edward Teller, and Eugene Wigner jumped into action, persuading Albert Einstein, a celebrity, to write President Franklin D. Roosevelt a letter of caution. In 1940 Frisch and Rudolf Peierls produced the Frisch–Peierls memorandum, which first set out how an atomic explosion could be generated, and this ultimately led to the establishment in 1942 of the Manhattan Project. Meitner refused an offer to work on the project at Los Alamos, declaring "I will have nothing to do with a bomb!"[37] Meitner said that Hiroshima had come as a surprise to her, and that she was "sorry that the bomb had to be invented".[38]

In Sweden, Meitner was first active at Siegbahn's Nobel Institute for Physics, and at the Swedish National Defence Research Institute (FOA) and the Royal Institute of Technology in Stockholm, where she had a laboratory and participated in research on R1, Sweden's first nuclear reactor. In 1947, a personal position was created for her at the University College of Stockholm with the salary of a professor and funding from the Council for Atomic Research.[39]

Nobel Prize for nuclear fission

The many honors that Meitner received in her lifetime have long been overshadowed by the fact that she did not share the Nobel Prize for nuclear fission awarded to Otto Hahn. On 15 November 1945, the Royal Swedish Academy of Sciences announced that Hahn had been awarded the 1944 Nobel Prize in Chemistry for "his discovery of the fission of heavy atomic nuclei".[40]

At the time Meitner herself wrote in a letter, "Surely Hahn fully deserved the Nobel Prize for chemistry. There is really no doubt about it. But I believe that Otto Robert Frisch and I contributed something not insignificant to the clarification of the process of uranium fission—how it originates and that it produces so much energy and that was something very remote to Hahn."[41] In a similar vein, Carl Friedrich von Weizsäcker, Lise Meitner's former assistant, later added that Hahn "certainly did deserve this Nobel Prize. He would have deserved it even if he had not made this discovery. But everyone recognized that the splitting of the atomic nucleus merited a Nobel Prize."[42] Frisch wrote similarly in a 1955 letter.[43]

Hahn's receipt of a Nobel Prize was long expected. Both he and Meitner had been nominated for both the chemistry and the physics prizes several times even before the discovery of nuclear fission.[44][45] In 1945 the Committee in Sweden that selected the Nobel Prize in Chemistry decided to award that prize solely to Hahn. In the 1990s, the long-sealed records of the Nobel Committee's proceedings became public, and the comprehensive biography of Meitner published in 1996 by Ruth Lewin Sime took advantage of this unsealing to reconsider Meitner's exclusion.[46] In a 1997 article in the American Physical Society journal *Physics Today*, Sime and her colleagues Elisabeth Crawford and Mark Walker wrote: "It appears that Lise Meitner did not share the 1944 prize because the structure of the Nobel committees was ill-suited to assess interdisciplinary work; because the members of the chemistry committee were unable or unwilling to judge her contribution fairly; and because during the war the Swedish scientists relied on their own limited expertise. Meitner's exclusion from the chemistry award may well be summarized as a mixture of disciplinary bias, political obtuseness, ignorance, and haste."[8]

Max Perutz, the 1962 Nobel prizewinner in chemistry, reached a similar conclusion: "Having been locked up in the Nobel Committee's files these fifty years, the documents leading to this unjust award now reveal that the protracted deliberations by the Nobel jury were hampered by lack of appreciation both of the joint work that had preceded the discovery and of Meitner's written and verbal contributions after her flight from Berlin."[9]

Later years

After the war, Meitner, while acknowledging her own moral failing in staying in Germany from 1933 to 1938, was bitterly critical of Hahn, Max von Laue and other German scientists who, she thought, would have collaborated with the Nazis and done nothing to protest against the crimes of Hitler's regime. Referring to the leading German nuclear physicist Werner Heisenberg, she said:

"Heisenberg and many millions with him should be forced to see these camps and the martyred people." In a June 1945 draft letter addressed to Hahn, but never received by him, she wrote:

> You all worked for Nazi Germany. And you tried to offer only a passive resistance. Certainly, to buy off your conscience you helped here and there a persecuted person, but millions of innocent human beings were allowed to be murdered without any kind of protest being uttered ... [it is said that] first you betrayed your friends, then your children in that you let them stake their lives on a criminal war – and finally that you betrayed Germany itself, because when the war was already quite hopeless, you did not once arm yourselves against the senseless destruction of Germany.[47]


Meitner's grave in Bramley

After the war in the 1950s and 1960s, Meitner again enjoyed visiting Germany and staying with Hahn and his family for several days on different occasions, particularly on March 8, 1959, to celebrate Hahn's 80th birthday in Göttingen, where she addressed recollections in his honour. Also Hahn wrote in his memoirs, which were published shortly after his death in 1968, that he and Meitner had remained lifelong close friends.[48] Even though their friendship was full of trials, arguably more so experienced by Meitner, she "never voiced anything but deep affection for Hahn."[49]

In 1947, Meitner retired from the Siegbahn Institute and started research in a new laboratory that was created specifically for her by the Swedish Atomic Energy Commission at the Royal Institute of Technology. She became a Swedish citizen in 1949. She retired in 1960 and moved to the UK where most of her relatives were, although she continued working part-time and giving lectures.

A strenuous trip to the United States in 1964 led to Meitner having a heart attack, from which she spent several months recovering. Her physical and mental condition weakened by atherosclerosis, she was unable to travel to the US to receive the Enrico Fermi prize and relatives had to present it to her. After breaking her hip in a fall and suffering several small strokes in 1967, Meitner made a partial recovery, but eventually was weakened to the point where she moved into a Cambridge nursing home.

She died in her sleep on 27 October 1968 at the age of 89.[6] Meitner was not informed of the deaths of Otto Hahn (d. July 1968) or his wife Edith, as her family believed it would be too much for someone so frail.[6] As was her wish, she was buried in the village of Bramley in Hampshire, at St. James parish church, close to her younger brother Walter, who had died in 1964. Her nephew Frisch composed the inscription on her headstone. It reads:

> Lise Meitner: a physicist who never lost her humanity

Awards and honours

On a visit to the USA in 1946, Meitner received the honour of "Woman of the Year" by the National Press Club and had dinner with President Harry Truman and others at the Women's National Press Club. She lectured at Princeton, Harvard and other US universities, and was awarded a number of honorary doctorates. She received jointly with Hahn the Max Planck Medal of the German Physical Society in 1949, and in 1955 she was awarded the first Otto Hahn Prize of the German Chemical Society. In 1957 the German President Theodor Heuss awarded her the highest German order for scientists, the peace class of the Pour le Mérite. She was nominated by Otto Hahn for both honours. Meitner's name was submitted, also by Hahn, to the Nobel Prize committee more than ten times, but she was not accepted.

Meitner was elected a foreign member of the Royal Swedish Academy of Sciences in 1945, and had her status changed to that of a Swedish member in 1951. Four years later she was elected a Foreign Member of the Royal Society (ForMemRS) in 1955.[3] She was elected a Foreign Honorary Member of the American Academy of Arts and Sciences in 1960.[50]

Meitner received 21 scientific honours and awards for her work (including 5 honorary doctorates and membership of 12 academies). In 1947 she received the Award of the City of Vienna for science. She was the first female member of the scientific class of the Austrian Academy of Sciences. In 1960, Meitner was awarded the Wilhelm Exner Medal and in 1967, the Austrian Decoration for Science and Art.

Meitner with actress Katharine Cornell and physicist Arthur Compton on 6 June 1946, when Meitner and Cornell were receiving awards from the National Conference of Christians and Jews

In 1966 Hahn, Fritz Strassmann and Meitner were jointly awarded the Enrico Fermi Award by President Lyndon B. Johnson and the United States Atomic Energy Commission (USAEC) in Washington D.C. Lise Meitner's diploma bears the words: *"For pioneering research in the naturally occurring radioactivities and extensive experimental studies leading to the discovery of fission."* Otto Hahn's diploma is different but essentially similar: *"For pioneering research in the naturally occurring radioactivities and extensive experimental studies culminating in the discovery of fission."*[51]

Since Meitner's 1968 death, she has received many naming honours. In 1997, element 109 was named meitnerium in her honour.[12][52][53] She is the first and so far only non-mythological woman thus honoured. (Curium was named after both Marie and Pierre Curie.) Additional naming honours are the Hahn–Meitner-Institut in Berlin, craters on the Moon and on Venus, and the main-belt asteroid 6999 Meitner.

Statue of Meitner (Anna Franziska Schwarzbach, 2014), Humboldt University in Berlin

In 2000, the European Physical Society established the biannual "Lise Meitner Prize" for excellent research in nuclear science.[54] In 2006 the "Gothenburg Lise Meitner Award" was established by the University of Gothenburg in Sweden; it is awarded annually to a scientist who has made a breakthrough in physics.[55] In 2008, the chemical, biological, radiological, and nuclear defense school of the Austrian Armed Forces (NBC) established the Lise Meitner Award.

In October 2010, a building at the Free University of Berlin was named the Hahn-Meitner Building; this was a renaming of a building previously known as the Otto Hahn Building.[56] In July 2014 a statue of Lise Meitner was unveiled in the garden of the Humboldt University of Berlin next to similar statues of Hermann von Helmholtz and Max Planck.[57]

A short residential street in Bramley, her resting place, is named Meitner Close.[58] Schools and streets were named after her in many cities in Austria and Germany.[59][60]

Since 2015 AlbaNova university centre in Stockholm has annual Lise Meitner Distinguished Lecture.

In 2017, the Advanced Research Projects Agency-Energy in the United States named a major nuclear energy research program in her honor.[61]

See also

- List of Austrian scientists
- Hans-Hermann Hupfeld
- List of German inventors and discoverers

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External links

- "Lise Meitner", "Contributions of 20th-Century Women to Physics" (CWP), University of California, Los Angeles
- Annotated bibliography for Lise Meitner from the Alsos Digital Library for Nuclear Issues
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