

= Maria Goeppert @-@ Mayer =

Maria Goeppert Mayer (June 28 , 1906 ? February 20 , 1972) was a German @-@ born American theoretical physicist , and Nobel laureate in Physics for proposing the nuclear shell model of the atomic nucleus . She was the second female Nobel laureate in physics , after Marie Curie .

A graduate of the University of Göttingen , Goeppert Mayer wrote her doctorate on the theory of possible two @-@ photon absorption by atoms . At the time , the chances of experimentally verifying her thesis seemed remote , but the development of the laser permitted this . Today , the unit for the two @-@ photon absorption cross section is named the Goeppert Mayer (GM) unit .

Maria Goeppert married Joseph Edward Mayer and moved to the United States , where he was an associate professor at Johns Hopkins University . Strict rules against nepotism prevented Johns Hopkins University from taking her on as a faculty member , but she was given a job as an assistant and published a landmark paper on double beta decay in 1935 . In 1937 , she moved to Columbia University , where she took an unpaid position . During World War II , she worked for the Manhattan Project at Columbia on isotope separation , and with Edward Teller at the Los Alamos Laboratory on the development of the Teller 's " Super " bomb .

After the war , Goeppert Mayer became a voluntary associate professor of Physics at the University of Chicago (where Teller and her husband worked) and a senior physicist at the nearby Argonne National Laboratory . She developed a mathematical model for the structure of nuclear shells , for which she was awarded the Nobel Prize in Physics in 1963 , which she shared with J. Hans D. Jensen and Eugene Wigner . In 1960 , she was appointed full professor of physics at the University of California at San Diego .

= = Early life = =

Maria Göppert was born on June 28 , 1906 , in Kattowitz (now Katowice , Poland) , a city in Prussia , the only child of Friedrich Göppert and his wife Maria née Wolff . In 1910 , she moved with her family to Göttingen when her father , a sixth @-@ generation university professor , was appointed as the professor of pediatrics at the University of Göttingen . Goeppert was closer to her father than her mother . " Well , my father was more interesting , " she later explained . " He was after all a scientist . "

Göppert was educated at the Höhere Technische in Göttingen , a school for middle @-@ class girls who aspired to higher education . In 1921 , she entered the Frauenstudium , a private high school run by suffragettes that aimed to prepare girls for university . She took the abitur , the university entrance examination , at age 17 , a year early , with three or four girls from her school and thirty boys . All the girls passed , but only one of the boys did .

In the Spring of 1924 , Göppert entered the University of Göttingen , where she studied mathematics . A purported shortage of women mathematics teachers for schools for girls led to an upsurge of women studying mathematics at a time of high unemployment , and there was even a female professor of mathematics at Göttingen , Emmy Noether , but most were only interested in qualifying for their teaching certificate .

Instead , Goeppert became interested in physics , and chose to pursue a Ph.D. In her 1930 doctoral thesis she worked out the theory of possible two @-@ photon absorption by atoms . Eugene Wigner later described the thesis as " a masterpiece of clarity and concreteness " . At the time , the chances of experimentally verifying her thesis seemed remote , but the development of the laser permitted the first experimental verification in 1961 when two @-@ photon @-@ excited fluorescence was detected in a europium @-@ doped crystal . To honor her fundamental contribution to this area , the unit for the two @-@ photon absorption cross section is named the Goeppert @-@ Mayer (GM) unit . One GM is 10^{-28} cm² s photon⁻¹ . Her examiners were three future Nobel prize winners : Max Born , James Franck and Adolf Otto Reinhold Windaus .

On January 19 , 1930 , Goeppert married Joseph Edward Mayer , an American Rockefeller fellow who was one of James Franck 's assistants . The two had met when Mayer had boarded with the Goeppert family . The couple moved to Mayer 's home country of the United States , where he had

been offered a position as associate professor of chemistry at Johns Hopkins University . They had two children , Maria Ann and Peter Conrad .

= = United States = =

Strict rules against nepotism ostensibly prevented Johns Hopkins University from hiring Goeppert Mayer as a faculty member , but she was given a job as an assistant in the Physics Department working with German correspondence . She received a very small salary , a place to work and access to the facilities . She taught some courses , published an important paper on double beta decay in 1935 .

There was little interest in quantum mechanics at Johns Hopkins , but Goeppert Mayer worked with Karl Herzfeld , collaborating on a number of papers . She also returned to Göttingen in the summers of 1931 , 1932 and 1933 to work with her former examiner Born , writing an article with him for the Handbuch der Physik . This ended when the NSDAP came to power in 1933 , and many academics , including Born and Franck , lost their jobs . Goeppert Mayer and Herzfeld became involved in refugee relief efforts .

Joe Mayer was fired in 1937 . He attributed this to the hatred of women on the part of the dean of physical sciences , which he thought was provoked by Goeppert Mayer 's presence in the laboratory . Herzfeld agreed and added that , with Goeppert Mayer , Franck and Herzfeld all at Johns Hopkins , some thought that there were too many German scientists there . There were also complaints from some students that Mayer 's chemistry lectures contained too much modern physics . Mayer took up a position at Columbia University , where the chairman of the Physics Department , George B. Pegram , arranged for Goeppert Mayer to have an office , but she received no salary . She soon made good friends with Harold Urey and Enrico Fermi , who arrived at Columbia in 1939 . Fermi asked her to investigate the valence shell of the undiscovered transuranic elements . Using the Thomas ? Fermi model , she predicted that they would form a new series similar to the rare earth elements . This proved to be correct .

= = Manhattan Project = =

In December 1941 , Goeppert Mayer took up her first paid professional position , teaching science part @-@ time at Sarah Lawrence College . In the spring of 1942 , with the United States embroiled in World War II , she joined the Manhattan Project . She accepted a part @-@ time research post from Urey with Columbia University 's Substitute Alloy Materials (SAM) Laboratories . The objective of this project was to find a means of separating the fissile uranium @-@ 235 isotope in natural uranium ; she researched the chemical and thermodynamic properties of uranium hexafluoride and investigated the possibility of separating isotopes by photochemical reactions . This method proved impractical at the time , but the development of lasers would later open the possibility of separation of isotopes by laser excitation .

Through her friend Edward Teller , Goeppert Mayer was given a position at Columbia with the Opacity Project , which researched the properties of matter and radiation at extremely high temperatures with an eye to the development of the Teller 's " Super " bomb , the wartime program for the development of thermonuclear weapons . In February 1945 , Joe was sent to the Pacific War , and Goeppert Mayer decided to leave her children in New York and join Teller 's group at the Los Alamos Laboratory . Joe came back from the Pacific earlier than expected , and they returned to New York together in July 1945 .

In February 1946 , Joe became a professor in the Chemistry Department and the new Institute for Nuclear Studies at the University of Chicago , and Goeppert Mayer was able to become a voluntary associate professor of Physics at the school . When Teller also accepted a position there , she was able to continue her Opacity work with him . When the nearby Argonne National Laboratory was founded on July 1 , 1946 , Goeppert Mayer was also offered a part @-@ time job there as a senior physicist in the Theoretical Physics Division . She responded " I don 't know anything about nuclear physics . " She programmed the Aberdeen Proving Ground 's ENIAC to solve criticality problems for

a liquid metal cooled reactor using the Monte Carlo method .

= = Nuclear shell model = =

During her time at Chicago and Argonne in the late 1940s , Goeppert Mayer developed a mathematical model for the structure of nuclear shells , which she published in 1950 . Her model explained why certain numbers of nucleons in an atomic nucleus result in particularly stable configurations . These numbers are what Eugene Wigner called magic numbers : 2 , 8 , 20 , 28 , 50 , 82 , and 126 . Enrico Fermi provided a critical insight by asking her : " Is there any indication of spin orbit coupling ? " She realised that this was indeed the case , and postulated that the nucleus is a series of closed shells and pairs of neutrons and protons tend to couple together . She described the idea as follows :

Think of a room full of waltzers . Suppose they go round the room in circles , each circle enclosed within another . Then imagine that in each circle , you can fit twice as many dancers by having one pair go clockwise and another pair go counterclockwise . Then add one more variation ; all the dancers are spinning twirling round and round like tops as they circle the room , each pair both twirling and circling . But only some of those that go counterclockwise are twirling counterclockwise . The others are twirling clockwise while circling counterclockwise . The same is true of those that are dancing around clockwise : some twirl clockwise , others twirl counterclockwise .

Three German scientists , Otto Haxel , J. Hans D. Jensen , and Hans Suess , were also working on solving the same problem , and arrived at the same conclusion independently . Their results were announced in the issue of the Physical Review before Goeppert Mayer ' s announcement in June 1949 . Afterwards , she collaborated with them . Hans Jensen co -@-@ authored a book with Goeppert Mayer in 1950 titled Elementary Theory of Nuclear Shell Structure . In 1963 , Goeppert Mayer , Jensen , and Wigner shared the Nobel Prize for Physics " for their discoveries concerning nuclear shell structure . " She was the second and most recent female Nobel laureate in physics , after Marie Curie .

= = Death and legacy = =

In 1960 , Goeppert Mayer was appointed full professor of physics at the University of California at San Diego . Although she suffered from a stroke shortly after arriving there , she continued to teach and conduct research for a number of years . She was elected a Fellow of the American Academy of Arts and Sciences in 1965 . Goeppert Mayer died in San Diego , California , on February 20 , 1972 , after a heart attack that had struck her the previous year left her comatose . She was buried at El Camino Memorial Park in San Diego .

After her death , the Maria Goeppert Mayer Award was created by the American Physical Society to honor young female physicists at the beginning of their careers . Open to all female physicists who hold Ph.D.s , the winner receives money and the opportunity to give guest lectures about her research at four major institutions . Two of her former universities also honor her . The Argonne National Laboratory presents an award each year to an outstanding young woman scientist or engineer , while the University of California at San Diego hosts an annual Maria Goeppert Mayer symposium , bringing together female researchers to discuss current science . Crater Goeppert Mayer on Venus with a diameter of about 35 km is also named after Goeppert @-@ Mayer . In 2011 , she was included in the third issuance of the American Scientists collection of US postage stamps , along with Melvin Calvin , Asa Gray , and Severo Ochoa . Her papers are in the Geisel Library at the University of California , San Diego , and the university ' s physics department is housed in Mayer Hall , which is named after her and her husband .