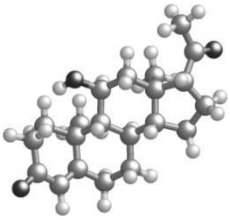

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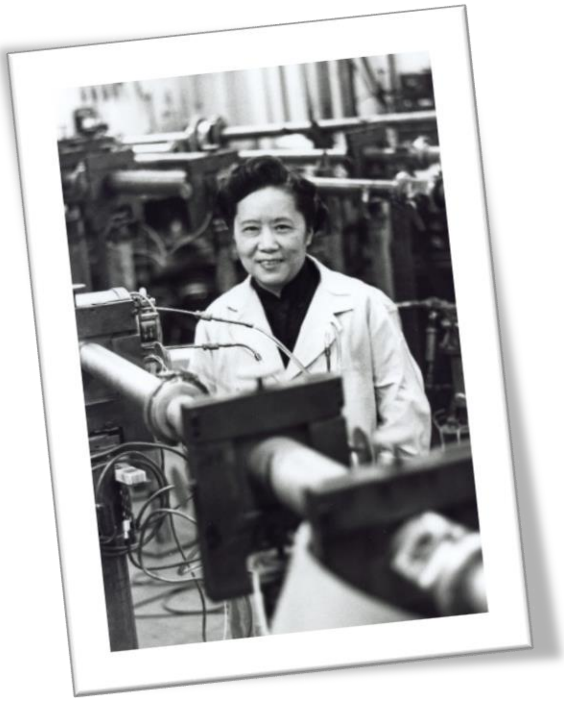
Biography #3 – Chien-Shiung Wu (1912 – 1997)



• Chien-Shiung Wu, 1912 – 1997.

One day early in the spring of 1956, theoretical physicist T. D. Lee climbed to the thirteenth floor of Columbia University's physics laboratory to consult his colleague Chien-Shiung Wu. Dr. Lee had a problem. He and his partner Dr. Yang wanted to test a new hypothesis that could turn nuclear physics on its head. Up to that time, every interaction observed in physics had been *symmetric*. That is, every interaction, if seen in a mirror, would look the same. But the idea of symmetry led to some mathematical difficulties when physicists considered the process of radioactive beta-decay, in which the nucleus of an atom spontaneously ejects an electron. No one, so far, had been able to show for sure whether beta-decay conserved or broke symmetry. So Dr. Lee did what any good theoretical physicist would do – he asked an experimental physicist.

There has always been interplay between theory and experimental physics. New experimental data may require complete rethinking of theory. Theorists use their imagination and mathematics to pose questions and come up with possible explanations, many of them very difficult to test. Experimentalists use their imagination, skill and knowledge of measurement to figure out ways to test hypothesis. In this case, Lee and Yang were nearly certain that beta-decay would violate symmetry, but they thought the question should be tested.

Dr. Wu listened to Dr. Lee's questions and made a suggestion. At very low temperatures in a strong magnetic field, she thought it would be possible to detect asymmetric emissions of electrons from decaying Cobalt-60, if it occurred. So began a collaboration that led to a Nobel Prize.

Chien-Shiung Wu was born in the town of Liu He, China, not far from Shanghai. The name Chien-Shiung means "courageous hero," and Chien-Shiung's father had great aspirations for her. A former engineer, he believed so strongly in the education of girls that he started China's first private girls' elementary school, where he and his wife both taught. But the school went only as far as fourth grade, so at age nine, Chien-Shiung left home for boarding school in the canal-crossed city of Suzhou.

When it came time to choose a course in high school, Soochow Girls' School offered two pathways, an academic track and a Western-orientated course for teacher training. Chien-Shiung chose the chose the teacher track, and although she learned English and enjoyed lectures by visiting American professors, at times she regretted her choice. Girls in the academic track had access to interesting books in chemistry, physics and mathematics. So at night in their shared dormitory room, Chien-Shiung borrowed and read her schoolmates' books.

In 1930, at the age of seventeen, Chien-Shiung graduated at the top of her high school class. That summer she learned that she had been selected to attend an elite university in Nanjing. She had a crisis of confidence. She knew she wanted to study physics, but she did not have the right preparation. Luckily, her father stepped in. The day after his daughter's acceptance, he brought home three books, one each of chemistry, physics and advanced mathematics. "Ignore the obstacles," Principal Wu told his daughter. "Just put your head down and keep walking forward." Chien-Shiung spent the rest of the summer studying. Years later, she said, "If it hadn't been for my father's encouragement, I would be teaching grade school somewhere in China now."

After graduating from the National Central University in Nanjing in 1934, Wu stayed on as an instructor while doing research in X-ray crystallography. But she wanted to get a Ph.D., so in 1936 she took a ship to the United States. Although she originally intended to study at the University of Michigan, she changed her mind when she learned the university did not allow women in the student union. Wu decided to attend Berkeley instead.

At Berkeley, Wu studied nuclear fission with such great nuclear physicists as Ernest Lawrence, who was building the first cyclotron, and Emilio Segre, who later discovered the antiproton. Both men later won Nobel Prizes. J. Robert Oppenheimer, who later directed the Manhattan Project to develop the atomic bomb, also worked at Berkeley. In both her classes and the laboratory, Wu was recognised as an outstanding student. She was elected to Phi Beta Kappa and received her Ph.D. in 1940. But she continued to face barriers because of her sex. In graduate school she missed out on a fellowship, probably because she was Asian and Female. After graduation, Berkeley kept her on as a research assistant, but did not appoint her to the faculty. At that time, no woman was teaching physics at any major American university.

Those years were difficult for another reason as well. In 1937, in the prelude to World War II, Japan invaded China. Wu lost all contact with her family. Only after the war did she learn they were safe. By that time there was civil war in China, and soon after came the Communist takeover. Wu did not return home, and she never saw her family again.

In 1942, Wu married a Berkeley classmate, Dr. Luke C. L. Yuan, and the couple moved east. Yuan got a research position at the Radio Corporation of America's laboratories in Princeton, New Jersey, and Wu taught for a few years at Smith College. By now, with so many men gone for the war, teaching positions suddenly opened up, and Wu received offers from Columbia, Princeton, and Massachusetts Institute of Technology. She took a job at Princeton, where she taught nuclear physics to naval officers. Then, in 1944, because of her knowledge of nuclear radiation, Columbia University recruited her to work on war research for the still secret Manhattan Project.

After the war, Wu continued as a research associate at Columbia. In 1947, she and Luke had a son, Vincent, who also grew up to be a physicist. They moved very close to the university so that Wu could run back and forth between the laboratory and her son. It was probably around this time that Wu first said, "There only one thing worse than coming home from the lab to a sink of dirty dishes, and that is not going to the lab at all." In 1952, Columbia appointed Wu associate professor in physics. She continued to delve into her speciality, beta-decay.

In 1956 and 1957, Wu worked on the experimental challenge Lee and Wang had posed. She enlisted the low temperature physics laboratory at the National Bureau of Standards to help. Together, they used liquid hydrogen and helium at low pressures to cool Cobalt-60 to 0.01 Kelvin, which is very close to absolute zero (approximately –273 °C). At such a low temperature, the atoms of cobalt moved very little. Then the experimenters magnetised the cobalt-60 atoms so that most of their nuclei spun in the same direction. To their amazement, they showed definitively that nuclei spinning one way ejected electrons in a different direction from nuclei spinning the opposite way. The mirror images looked different. The conservation of parity, or symmetry, until then thought to be universal in physics, was broken. The laboratory team popped the cork on a bottle of champagne. "These are moments of exaltation and ecstasy," Wu recalled later. "A glimpse of this wonder can be the reward of a lifetime."

The news was monumental in the world of physics. Wolfgang Pauli, hearing a report of it, exclaimed, "That's utter nonsense!" But other researchers confirmed the results. One of Wu's Columbia colleagues said, more mildly but with concern, "A rather complete theoretical structure has been shattered at the base, and we are not sure how the pieces will be put together." So important was the discovery that the Nobel Prize committee moved with unusual speed to award the Nobel Prize in Physics to Lee and Yang in 1957. To the consternation of many in the physics community, Wu was not included in the prize. Purportedly, the reason was that she had "only" done the experiment to confirm the original ideas of others.

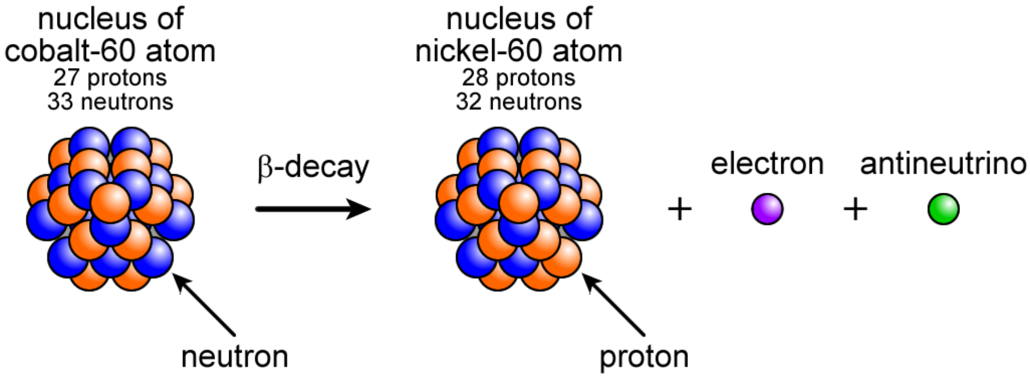
Although extremely disappointed about the Nobel Prize, Wu won a long string of other prizes: the first Wolf Prize from Israel, the first Comstock Prize awarded to a woman, and many others.

And she continued her productive line of research. Graduate students sought her out as a research mentor despite her reputation as a “slave driver” who expected them to spend long hours in the laboratory seven days a week. The awards and honours kept pouring in. Columbia made her a full professor. Princeton awarded her an honorary doctorate, their first ever to a woman in science. She became the seventh woman ever elected to the National Academy of Sciences.

In 1963, Wu experimentally confirmed a theory of two later Nobel Prize awardees, Richard Feynman and Murray Gell-Mann. Two years later, she published *Beta Decay*, which became a standard text in nuclear physics. In 1976, The American Physical Society elected her as their first woman president, and that same year President Ford awarded her the National Medal of Science.

After her retirement in 1981, Wu continued to lecture and teach. She spoke up often about barriers to women in science, especially the physical sciences. She even became the first living scientist to have an asteroid named after her.

Chien-Shiung Wu died of a stroke in 1997 at the age of eighty-four. One former colleague said of the small woman from China, “C. S. Wu was one of the giants of physics.” And her entry in the National Women’s Hall of Fame reads that she had, “Radically altered modern physical theory and changed our accepted view of the structure of the universe.”



• The process of beta-decay.

Atoms consist of protons and neutrons in a tightly packed nucleus surrounded by clouds or shells of electrons. The number of protons in the nucleus determines the atom’s chemical nature – whether it’s an atom of gold or oxygen. But physicists discovered early in the twentieth century that in some cases, an atom of one element can spontaneously transform into an atom of another element, giving off radiation as it does so. Three possible types of radiation – alpha, beta and gamma – can be emitted during the process.

Beta radiation, or beta-decay occurs when an atom spontaneously ejects an electron from its nucleus. With this beta emission, one of the neutrons in the nucleus becomes a proton, changing the atom into a different element with one more proton. For example, an atom of carbon (with 6 protons) can become an atom of nitrogen (with 7 protons). The question that Lee and Yang posed, and which Wu’s experiment answered, was whether the electrons in beta-decay are ejected equally in all directions.

• Noyce, P. (2015). *Magnificent Minds* (pp. 125-129). Boston, MA: Tumble Home Learning, Inc.