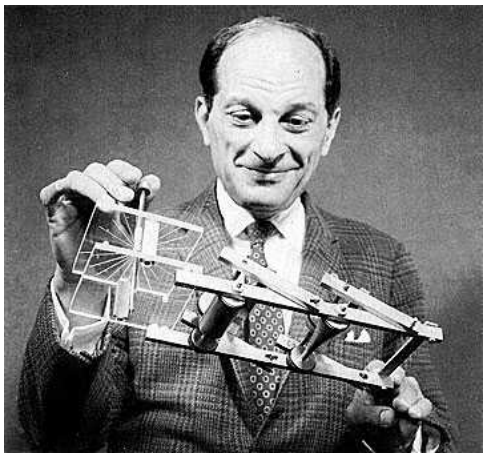
Stanislaw Marcin Ulam



When Polish-born American mathematician **Stanislaw Marcin Ulam** (April 3, 1909 – May 13, 1984) decided to devote himself to mathematics, he believed he was embarking on a career in pure thought, uncomplicated by practical considerations. Instead he found himself recruited into one of the most frighteningly practical projects ever untaken – the Manhattan Project that ushered the world into the atomic age. In 1943 he joined a team of the world's leading physicists, chemists and mathematicians at Los Alamos, New Mexico. His major contribution to the project was testing the theories and designs of physicists and other mathematicians. He employed mathematics to develop the means for simulating the nuclear reaction that would take place in the atomic bomb. While working on a fusion bomb, he and Edward Teller developed a two-stage radiation implosion design, which could generate an explosion capable of initiating nuclear fusion. Called the "Teller-Ulam configuration," its design led to the creation of the hydrogen bomb. Beyond this work, Ulam was a gifted mathematician who made significant contributions to set theory, topology, ergodic theory, probability, cellular automata theory, real analysis, mathematical logic and number theory.

Ulam was born in Lvov, Poland, the son of lawyer Jozef Ulam and his wife Anna Auerbach, the daughter of an industrialist. At the age of 10 he entered the gymnasium with interests in astronomy and physics. In order to understand Einstein's special theory of relativity he studied mathematics on his own, quickly surpassing anything found in his courses. He mastered calculus by 16 and taught himself set theory from Wacław Sierpiński's book. Ulam received his masters and doctorate from the Polytechnic Institute in Lvov. Stefan Banach directed his 1933 thesis investigating a problem that originated with Henri Lebesgue in 1902. Ulam then traveled to Vienna, Zurich, and Cambridge to

pursue post-doctorial studies. He developed a reputation as an original mathematician, and in 1935, at the invitation of John von Neumann, he visited the Institute of Advanced Study at Princeton. There Ulam met G.D. Birkhoff, who brought him to Harvard as one of the earliest members of the Society of Fellows (1936-1939). Ulam traveled back and forth between the United States and Poland spending his summers visiting with family and friends and doing mathematics at the Scottish Café and Roma Café. Ulam and his sixteen-year-old brother Adam left Poland for good in 1939. They made their farewells to their father and uncle. It was the last time either saw the two men. In 1945, Stan received a letter from a cousin informing him that his immediate family, including, father, sister, brother-in-law and uncle "all fell under the hands of the Nazis."

In 1940, Ulam moved to the University of Wisconsin as an assistant professor of mathematics. Three years later he became a naturalized American citizen and received a letter from physicist Hans Bethe offering him a job doing some war work. Anxious to assist his new country against the Fascists, Ulam accepted the offer even though, as he remembered, Bethe's letter was cryptic.

> "I received an official invitation to join an unidentified project that was doing important work, the physics having something to do with the interior of stars."

Ulam met von Neumann at a railroad station in Chicago where he learned a bit more about the important work. At the time von Neumann was not prepared to say where Ulam would be located or what exactly he would be doing. A few months later Ulam and his wife arrived at Los Alamos, New Mexico, where the assignment was to make an atomic bomb. Ulam's particular assignment was to solve the implosion problem, which involved calculating the actions of several explosions to some workable mathematical model. His solution was to surround the plutonium core with high explosives. The high explosives were cast into spheres, called lenses, and wired so they would all fire at the same instant. The pressure caused from the explosions on all sides of the sphere focused the shock waves on

the plutonium core. The plutonium core compressed in on itself until it reached critical mass and exploded. The feasibility of the method was proven during the Trinity test.

Early in the 1940s Ulam and von Neumann developed the Monte Carlo simulation method, an extremely useful calculating tool that enables mathematicians to attack complicated problems by making approximations using a statistical sampling method with random numbers. Ulam and the other Los Alamos mathematicians used the method in the analysis of complex nuclear phenomena. When neutrons are released in a reactor, some scatter, some are absorbed, others escape or collide. The actual process is too complex for analytical calculation. However, if the fate of a sufficient number of neutrons is followed, and at each branch one outcome with a realistic probability is selected, it is possible to derive a reasonably accurate mathematical model of the process. When von Neumann and Ulam first used the expression "Monte Carlo," it was a code name for their secret work at Los Alamos, suggested by the gambling casinos in Monte Carlo in Monaco. The procedure consists of constructing an artificial model of a problem and then performing sampling experiments. Although the methods used vary from field to field, all that is required for a "Monte Carlo" experiment is the use of random numbers, sampling techniques, and approximating outcomes in exploring some problem. Monte Carlo methods are widely used in computer implementations of mathematical software. With Monte Carlo methods, a large system can be sampled by a number of random configurations, and these data used to describe the system as a whole. Ulam's work at Los Alamos could have used modern computers, but initially he had to rely on human computers to crunch numbers. Ulam's wife Françoise Aron, a French exchange student at Mount Holyoke College was one such computer. The computer MANIAC, which became functional during the several months' work of simulation at Los Alamos, was developed especially for use by the Los Alamos project in the Monte Carlo simulation of the atomic bomb.

When the war ended, Ulam accepted a teaching position at the University of Southern California. One

night in the winter of 1945 he had a violent headache. When he tried to talk he could produce nothing but a meaningless mumble. He was rushed to a hospital where a surgeon drilled a hole in his skull and found his brain acutely inflamed. Ulam lapsed into a coma. The diagnosis was viral encephalitis. Friends and family wondered if exposure to radiation might have been the cause of his illness, but it was decided he had never had contact with radioactive material. Authorities were concerned that while unconscious Ulam might have given away nuclear secrets. It was feared that he would suffer permanent brain damage, and when he came out of the postoperative coma after a few days, he was concerned that he had lost his mathematical knowledge and reasoning powers. As he recovered, it became clear that the illness had not affected his imagination, and in time he once again was coming up with remarkable new ideas. However, he no longer was able to manage details in developing these ideas and had to depend upon others for technical support.

After a brief stint at Southern California, Ulam returned to the weapons laboratory at Los Alamos. In 1950 the United States embarked on an all-out effort to develop a hydrogen bomb. It was Ulam's assignment to calculate whether physicist Edward Teller's design for a fusion bomb was feasible. Ultimately Ulam and mathematician Cornelius Everett concluded that it would not work. This caused tension between Ulam and Teller. About a year later Ulam accidentally came up with a theoretical breakthrough. He reluctantly told it to Teller, who, although seeing certain problems with the scheme, recognized that this was the solution to their problems. Together Ulam and Teller converted the idea into a workable design for the thermonuclear bomb in 1952.

From 1965 to 1975 Ulam was professor and Chairman of the Mathematics Department at the University of Colorado. In 1973 he was appointed as a Graduate Research Professor at the University of Florida. Six years later he returned to the University of Colorado as Research Professor of Biomathematics. Ulam, who died in Santa Fe, New Mexico on May 13, 1984, published more than 150

papers, reports, and reviews in journals reflecting his diverse work in mathematics, theoretical physics, and mathematical biology. He wrote a fascinating autobiography *Adventures of a Mathematician* (1976), in which he recalled:

> "These were the last days of August [1939] … Adam and I were staying in a hotel on Columbus Circle. It was a very hot and humid New York night. I could not sleep very well. It must have been around 1:00 in the morning when the telephone rang. Dazed and perspiring, very uncomfortable, I picked up the receiver, and the somber, throaty voice of my friend, the topologist Witold Hurewicz, began to recite the horrible tale of the start of the war: 'Warsaw has been bombed, the war has begun,' he said. He kept describing what he had heard on the radio. Adam was asleep; I did not wake him. There would be time enough to tell him the news in the morning. Our father and sister were in Poland, so were many other relatives. At that moment, I suddenly felt as if a curtain had fallen on my past life, cutting it off from my future. There has been a different color and meaning to it ever since."

Quotation of the Day: "[Mathematicians] are the makers of signs which they hope will fit all contingencies." – Stanislaw M. Ulam