THE NOBEL PRIZE WINNERS

Physics

Volume 3
1968–1988

Edited by
FRANK N. MAGILL

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1968

Physics

Luis W. Alvarez, United States

Chemistry

Lars Onsager, United States

Physiology or Medicine

Robert W. Holley, United States
H. Gobind Khorana, United States
Marshall W. Nirenberg, United States

Literature

Yasunari Kawabata, Japan

Peace

René Cassin, France

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LUIS W. ALVAREZ
1968

Born: San Francisco, California; June 13, 1911
Died: Berkeley, California; September 1, 1988
Nationality: American
Area of concentration: High-energy particle physics

Alvarez developed the hydrogen bubble chamber into a high-precision instrument for discovering and tracking previously unknown fundamental particle resonances

The Award

Presentation

Professor S. von Friesen, a member of the Royal Swedish Academy of Sciences, presented the Nobel Prize in Physics to Luis W. Alvarez at the December 10, 1968, ceremonies on behalf of the Academy and the King of Sweden, from whom Alvarez accepted the prize. Observing that Albert Einstein had suggested that matter was one of the forms in which energy manifested itself, von Friesen noted that this theory was not established experimentally until equipment had been developed to track changes in particles. The new particles discovered in the previous two decades were so small that it was impossible to see them, even with powerful magnification. They had to be tracked by the traces that they left as they moved.

Alvarez, of the Lawrence Livermore Radiation Laboratory at the University of California at Berkeley, had developed the hydrogen bubble chamber into a sensitive and precise device for tracking and measurement, von Friesen said. His work in experimental physics had made possible the discovery of new elementary particles. In 1960, Alvarez and his colleagues discovered the first "resonance" particle; later, a number of discoveries were made by other research teams using the methods and equipment perfected by Alvarez. He also developed a system for transforming data from photographic film into a state suitable for analysis by a computer. Nearly all the important work in high-energy physics, von Friesen noted, had been furthered by the use of techniques originated and perfected by Alvarez.

Nobel lecture

In his lecture, delivered on December 11, 1968, and titled "Recent Developments in Particle Physics," Alvarez acknowledged that the experimental physicist, on the one hand, loves the tools used in experimentation and, on the other, dreams of making new discoveries. If he becomes too committed to the development of equipment, he risks losing sight of the implications of his experimentation. Nevertheless, Alvarez said, progress in particle physics had occurred because of painstaking research on equipment that provided better means of charting and measuring particles. For this reason, on behalf of his research team, Alvarez applauded the Royal Swedish Academy for recognizing in their citation both of the important concerns of the experimental physicist: the "observation of a new group of particles and the creation of the means for making those observations."

In keeping with these introductory remarks, Alvarez attempted to describe the way in which new information depends on the interrelationship of experiment, observation, and theory. Noting that when he received his bachelor of science degree in 1932, only three of the fundamental particles of physics were known, he charted the unsteady progress of the field of particle physics. He emphasized that new developments in hardware had not resulted in progress until the software had caught up and it was possible to compute statistical methods for evaluating experimental data.

Remarkably generous in the credit he gave to the contributions of his research team, Alvarez also mentioned that Ernest Orlando Lawrence, winner of the physics prize for 1939, had established the principle that the Berkeley Radiation Laboratory would share its resources with other scientists. This cooperation became a policy, and Alvarez observed that it had allowed the laboratory to participate vicariously in a number of discoveries of new particles.

Critical reception

In the United States, the news that Alvarez had won the Nobel Prize in Physics and that American chemist Lars Onsager had won for chemistry was received enthusiastically. Not since 1946 had the United States swept awards in all the Nobel science categories. (Americans won the award in physiology or medicine, as well.) The caption under Alvarez's picture in *The New York Times* of October 31 read, "A bit of a swashbuckler," and the caption for Onsager read, "Quiet and unassuming." The press found in Alvarez and Onsager two personalities that could be contrasted. The American public was accustomed to the image of a scientist as a quiet intellectual who found comfort in solitude and a second home in his laboratory. Alvarez was new. To exploit this phenomenon, the press depicted Alvarez as a cross between Errol Flynn and Thomas Alva Edison. Here was a scientist about whom people could get excited: He was spontaneous and unconventional, and he symbolized adventure and discovery.

As *The Times* of London noted, Alvarez was one of the first scientists to rely on large-scale scientific equipment to explore the ever-more-minute world of the atom; yet, he was averse to becoming a slave to these new devices. To the delight of the press, he emphasized his love of life outside his laboratory. He was quoted in *The New York Times* as saying, "I probably would be a better physicist if I turned long hair and stayed in the laboratory on Saturday night and Sundays, but I prefer to be a man as well as a physicist." Because of his intellectual curiosity, Alvarez had contributed to fields as diverse as archaeology and geology, another dimension of his personality that made him appealing to the general public.

Glenn Seaborg, who shared with Edwin McMillan the 1951 Nobel Prize in Chemistry, had recommended that Donald Glaser and Alvarez share the prize for the creation and development of the hydrogen bubble chamber. He pointed out that there was precedent for the inventor and developer to share the prize. Glaser alone, however, won the physics prize in 1960; the Nobel Committee had determined that

Alvarez's contributions did not merit an award. In his autobiography, *Alvarez: Adventures of a Physicist* (1987), Alvarez comments: "I had been considered by the Nobel committee and found wanting. That is something few physicists ever hear; nor have many seen that judgment reversed." The Nobel Committee awarded the 1968 Nobel Prize to Alvarez because of his many and varied scientific contributions. As many of the newspapers noted, Alvarez is named on forty U.S. patents, ranging from radar devices that allow direction to be determined by radio, to a color television system, to a golf training device. His wide-ranging interests and achievements captured the imagination of the public.

In Stockholm, Alvarez's energetic and dynamic personality made him extremely popular with the Swedish press. *The New York Times* of December 11 reported on his press conference after the award presentation, in which he enthusiastically told reporters about future developments that he expected in science. He vividly described his archaeological expedition to Egypt to determine if there were other tombs beneath the pyramids. He anticipated a not-too-distant future in which commuter shuttles would make routine trips to the Moon in order to maintain scientific equipment there.

Biography

Luis Walter Alvarez was born in San Francisco, California, on June 13, 1911, of Irish and Spanish immigrants. His mother, who came from a missionary family, had spent her early years in China. His father, a physician, divided his time between physiological research in the mornings and private practice in the afternoons. Alvarez attended San Francisco Polytechnic High School, a school catering to those interested in mechanical training. After his father received a research appointment at the Mayo Clinic, Alvarez attended Rochester High School, in Minnesota. During his youth, frequent hiking trips gave him a love of adventure and exploration which influenced his professional work and his work outside physics.

At the University of Chicago, majoring in chemistry, Alvarez realized that neither chemistry nor mathematics was a field which suited his inclinations and abilities. When he settled on physics, he discovered that textbooks merely distilled original scientific articles, and so he became an avid reader of original research. Near the end of his undergraduate career, Alvarez experimented with building an early version of the Geiger counter. His interest in optics and cosmic rays led to his codiscovery with Arthur Holly Compton of the "East-West effect" in cosmic rays early in his graduate career. After completing his master of science degree in 1934 and his doctorate in 1936 at the University of Chicago, he joined the Radiation Laboratory of the University of California at Berkeley, spearheaded by Ernest Lawrence, who became Alvarez's lifelong friend.

Scientific Career

Although his Nobel Prize was awarded for his work in high-energy particle physics, Luis Alvarez participated in most of the important developments in pure and applied science during his wide-ranging career. After completing his education in 1937, in spite of lucrative offers from distinguished universities and Bell Telephone Laboratories, Alvarez decided to work at the Berkeley Radiation Laboratory. Ernest Lawrence headed the laboratory, but it was also a home base for J. Robert Oppenheimer at the outset of his career and was visited by Enrico Fermi and every other major figure in physics.

During World War II, from 1940 until 1943, Alvarez was on leave at the Radiation Laboratory of the Massachusetts Institute of Technology, working on radar. He was responsible for three developments: the microwave early-warning system, the Eagle high-altitude bombing system, and a blind landing system. He developed a beam which would assist airplanes blinded by fog to land. From 1943 to 1944, he was on leave at the Metallurgical Laboratory of the University of Chicago. There he worked with Fermi on nuclear reactors, returning to the more theoretical problems with which his career had begun. He spent the last years of the war, 1944 and 1945, at the Los Alamos, New Mexico, laboratory of the Manhattan Project, working on the atom bomb. At Los Alamos, he developed the detonators for setting off the plutonium bomb. He flew as a scientific observer at both the Alamogordo and Hiroshima explosions. Unlike Oppenheimer and some other members of the Los Alamos community of scientists, Alvarez never came to regard the dropping of the bomb as a mistake. He remained convinced that the use of nuclear force was necessary to bring an end to World War II and to prevent World War III.

After the war, Alvarez returned to Berkeley to resume his career, but he was not allowed to retreat into his laboratory. He continued to be called on to act as an administrator until well into the 1950's. After the Soviet Union exploded an atom bomb, he was drawn into the controversy over the development of the hydrogen bomb. In this controversy, he sided with his Berkeley colleague Edward Teller. His position was difficult. He deeply believed in the efficacy of superior weapon power as a deterrent to war, and he supported what came to be called the "super" (the hydrogen bomb); in the Oppenheimer trials, however, he adopted the complex position of supporting ongoing thermonuclear research but defending the loyalty and integrity of Oppenheimer.

Because of his war efforts and continued involvement in defense research after the war, Alvarez lost touch with his chosen field, experimental physics. In his autobiography, he explains the problems that he faced in resuming his career and beginning the work on particle physics that led ultimately to his Nobel Prize:

> I still understood nuclear physics well. I wasn't successfully keeping abreast of particle physics, a rapidly expanding field. If not for my professorship I would probably have spent the rest of my days as an accelerator physicist, where I had demonstrated some talent.

Alvarez's Nobel Prize was awarded in particle physics. His career demonstrates that a scientist with a strong commitment to research can continue to make contributions throughout his life.

When Alvarez visited the Egyptian pyramids in the summer of 1962, he tried to imagine how the pyramids were built. It was not until 1964, when he was stationed in the Antarctic, that he had an opportunity to concentrate on the subject. On his return to Berkeley, Alvarez perused a large number of books on the subject and learned that Chephren's Pyramid had no chambers other than the burial chamber. The pyramids of Chephren's grandfather, Snefru, and father, Cheops, had two and three chambers respectively. Alvarez believed that, given human nature, Chephren's Pyramid should have at least four chambers. His theory was based on his intuitions about human behavior, but he brought to bear his knowledge of physics to test his hypothesis. In what may have been the first practical application of cosmic rays, he used cosmic-ray muons to probe the body of the pyramid for undiscovered chambers. This project was interrupted by the Egyptian-Israeli Six-Day War but resumed thereafter. For two days, Alvarez thought that a grand burial chamber had been discovered, but a reexamination of the data indicated that the pyramid was solid. He reported that people frequently remarked to him that they had heard that no chambers had been found, that the results were negative. To emphasize that even negative results can be useful, he insisted that the project had discovered that there was no chamber. The method worked; if there had been chambers in Chephren's pyramid, their investigation would have discovered them. Because of the methods pioneered by Alvarez, archaeologists can now penetrate the seemingly unpenetrable.

John F. Kennedy, a hero to many Americans, was especially so to Luis Alvarez. When the Warren Report on Kennedy's assassination appeared and was widely criticized, Alvarez decided to act as a scientific detective and discover as much about the facts of the assassination as he could. A few months after Kennedy's death, *Life* magazine published photographs of the assassination, which had been taken by Abraham Zapruder with eight-millimeter film. The film would later become the prime evidence in the Warren Commission investigation. Alvarez discovered from this film the timing of the bullets that hit Kennedy. This matter had come under some dispute, because although it was possible from the film to see the bullet that killed the president, the other two bullets still had to be accounted for. This discrepancy fueled the notion that there had been a second gunman. Using the same film, federal investigators could not pinpoint the exact time that the shots were fired. The investigators claimed that there were no reference points by which they could make any analysis, so their focus shifted to the audiotape of the gunshots.

Alvarez, who later became a member of the Committee on Ballistic Acoustics that analyzed the audiotape and discredited the theory of a second gunman, used some simple physics to demonstrate that the film corroborated that evidence. After carefully analyzing the positions of people in the film, Alvarez surmised that in the time frame of the film, anyone taking a step could be used to determine the speed of the limousine. To make his calculations, he also used the rate of hand clapping, the streaks of light reflected off the presidential limousine, and other kinds of evidence. His even more significant contribution, although he claimed that he had worked it out on the back of an envelope, was his proof that the president's body had fallen backward because of the law of the conservation of momentum, not because of a second gunman. In acting as a detective, Alvarez used the scientific method. He approached the problem as two quite independent procedures: the formulation of a hypothesis and the testing of that hypothesis.

In 1977, Alarez and his son Walter began an investigation of a 1-centimeter layer of clay that was sandwiched between two limestone strata containing large deposits of Cretaceous-Tertiary fossils. Such fossils were significantly absent within the sample. The clay deposit dated from the boundary between the Cretaceous and Tertiary periods, referred to as the "K/T boundary." Between the Cretaceous and Tertiary periods, the dinosaurs disappeared and modern flora, apes, and large mammals appeared. An analysis of the deposit prompted the Alvarez group to develop a theory of why the dinosaurs became extinct.

Alvarez and his son used a trace of iridium in the composition of the clay sample to determine how long it had taken for the clay to be deposited and so to calculate the time that had elapsed during the Cretaceous-Tertiary transition. These calculations served as a starting point for determining what forces had acted as catalysts, or extinction mechanisms, to bring about such a dramatic change. Iridium is basically an extraterrestrial substance. (All the iridium in Earth's crust is only one ten-thousandth of the iridium abundant in meteorites.) Alvarez selected iridium because it was the best material to use in determining the amount of debris that fell on Earth during this crucial period.

Iridium is deposited uniformly around Earth, and Alvarez wanted to account for these uniform deposits. He began with the theories of Sir George Stokes, who formulated the viscosity law, a calculation of the rate in which small particles fall in the air. Stokes had based this law on his observations of the fallout of ash from the eruption of Krakatoa. After discounting many possible hypotheses, such as a gigantic volcanic eruption, a supernova, or Earth's passing through a cosmic cloud of molecular hydrogen, Alvarez developed the hypothesis that an asteroid had collided with Earth.

According to his calculations, the asteroid had to be 10 kilometers in diameter. Its impact would have been catastrophic, far exceeding the worst nuclear scenario yet proposed. As Alvarez said, "The worst nuclear scenario yet proposed considers all fifty thousand nuclear warheads in U.S. and Russian hands going off more or less at once. That would be a disaster four orders of magnitude less violent than the K/T asteroid impact." Alvarez knew that the margin for error in discoveries, whether inventions or theories, was exponential, because of the possibility of mistakes in the data. As more data were collected from other sources, however, the argument only became stronger.

The asteroid hypothesis has not been fully accepted by the scientific community, but a number of predictions based on the theory have been verified experimentally and by computer simulation. The hypothesis has also been recognized by the influential National Academy of Sciences. The fourth part of the television series

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