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ROBERT SERBER
1909—1997

A Biographical Memoir by

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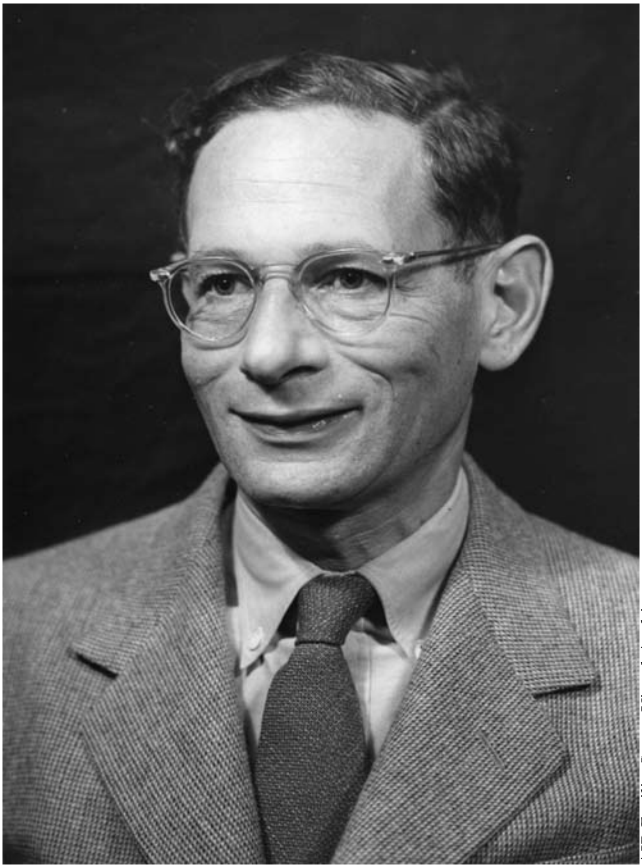
Biographical Memoir



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Robert Serber

ROBERT SERBER

March 14, 1909–June 1, 1997

BY ROBERT P. CREASE

ROBERT SERBER (elected to the NAS in 1952) was one of the leading theorists during the golden age of U.S. physics. He entered graduate school in 1930 before such key discoveries as the neutron, positron, and deuteron and prior to the development of the principal tool of nuclear and high-energy physics, the particle accelerator. He retired from the Columbia University Physics Department (as its chairman) in 1978 after completion of the standard model of elementary particle physics, which comprises almost all known particles and forces in a single package, and which has proven hard to surpass.

Shy and unostentatious, Serber did not mind being the detached spectator, and did not care when he was occasionally out of step with the mainstream, whether in politics or physics. Nevertheless, others regularly counted on him for advice: he was an insider among insiders. He seemed to carry the entire field of physics in his head, and his particular strength was a synthetic ability. He could integrate all that was known of an area of physics and articulate it back to others clearly and consistently, explaining the connection of each part to the rest. Although Serber made important contributions to several areas of physics—including quantum electrodynamics, particle physics, nuclear physics, and accelerator physics—his principal contribution was performing this synthetic task again and again. Scientists who can do it are far more influential than appears from publication or citation lists alone, and as essential to the education of newcomers as to the work of forefront researchers. Serber provided this synthetic service in the 1930s for graduate students at the University of California, Berkeley, where he was J. Robert Oppenheimer's chief research assistant; in the early 1940s for participants in the Manhattan Project; and in postwar years to colleagues at Berkeley, Brookhaven National Laboratory, Fermilab, and the other national laboratories.

Serber was born on March 14, 1909, in West Philadelphia, the eldest of three children. His father, David, had immigrated to the United States from Russia with his parents at the age of two; his mother, Rose, had been born in Philadelphia to a family that had immigrated from Poland. Rose died when Serber was 13, and his father remarried a few years later.

Serber grew up in an artistically and politically active Jewish community. Its center was at 322 South 16th Street, the home of Morris V. Leof, the uncle of his stepmother. Leftist figures who regularly dropped by the Leof salon included Clifford Odets, who gave readings of several of his plays there, and the budding journalist I. F. Stone. While Serber himself was temperamentally too reticent to be a political activist, the politics of members of this group later would haunt his career. Other occasional visitors to the Leofs included the then-famous physicist Wolfgang Pauli and in the late 1930s Katherine Puening, shortly to become the wife of J. Robert Oppenheimer. Serber would marry the youngest of the Leof's three children, Charlotte, in 1933.

In 1926 Serber graduated from Central High School in Philadelphia, which excelled in science, and entered Lehigh University, in Bethlehem, Pennsylvania, intending to become an engineer. He was quiet and kept to himself but was also often "unsophisticated and naïve," as he puts it in his memoir, *Peace and War* (1998). There he relates a remarkable story of his first day at Lehigh, when he received erroneous information about the location of his chemistry lab. He obediently went to the supposed room, found it empty but furnished with the necessary apparatus, and set to work. The same thing happened the next day, and the third, and throughout the semester. On the last day Serber hunted around for someone to hand in his work to, found a nearby bustling room—the correct one—and astonished the instructor by handing in the entire year's fully completed assignments. Evidently Serber had done his work well, for he won the prize for the highest grade average of the freshman class: a slide rule in a handsome leather case, a useful trophy that he would later use in calculations at Los Alamos. Historian Barton Bernstein has pointed out how revealing this anecdote is of Serber's character: "[I]t is the story of a psychologically passive, painfully shy, but intellectually energetic and self-motivated young man—not enterprising enough to ask about the whereabouts of the course, comfortably working on his own, presumably liking the isolation, and easily triumphing academically."[1]

Serber graduated from Lehigh in 1930. Though he had intended to follow in the footsteps of an uncle in becoming a mechanical engineer, he was more drawn to pure science courses, especially physics. He therefore turned down a job offer from Sperry Gyroscope Company and took a teaching assistantship at the University of Wisconsin at $800 a year. He was fortunate: 1930 was the last year any such teaching assistantship was available, as the Great Depression settled in. His mentor was John Van Vleck, a future Nobel laureate (in 1977). During the Depression, with no jobs to be had, the graduate students saw no logic in graduating, and the same crew stayed around to take more courses from Van Vleck: quantum mechanics, advanced quantum mechanics, and advanced quantum mechanics II.

Quantum mechanics was only three years old when Serber entered Wisconsin in 1930. It released a tremendous amount of intellectual energy in science, caused the foundations of several fields to be rewritten, and opened up hordes of new research problems in many areas. Shortly after Serber's arrival, Van Vleck assigned him the task of applying quantum mechanics to the Faraday effect, the rotation of the polarization of a beam of light by a magnetic field. The young graduate student presented his work to the American Physical Society at its 1931 Thanksgiving meeting in Chicago. Van Vleck insisted that Serber write it up and submit it to the *Physical Review*. This resulted in Serber's first publication, "The Theory of the Faraday Effect in Molecules." He would publish half a dozen papers as a graduate student, including ones on the application of quantum mechanics to the Kerr effect, on a technique for calculating statistical averages at a given temperature, and on a generalization of Dirac's method of calculating energy levels of many electron systems.

In 1934 Serber was awarded a National Research Council postdoctoral fellowship, which provided him with sufficient incentive to graduate. On Van Vleck's advice Serber initially decided to spend his fellowship with Eugene Wigner at Princeton. He and Charlotte, whom he had married the previous year, packed up their car and headed east. En route they stopped by the famous Ann Arbor summer school at the University of Michigan, established by Samuel Goudsmit and George Uhlenbeck, which was a major route by which news of European developments in quantum mechanics was imported into the United States. This was a turning point in

Serber's career for two reasons. It exposed him to the new ideas associated with Dirac's treatment of quantum mechanics and—more consequentially—it introduced him to J. Robert Oppenheimer.

In 1934 Oppenheimer was 30 years old and a mere 5 years senior to Serber. But this Wunderkind was already a key figure in U.S. physics, holding joint appointments at the University of California, Berkeley, where Oppenheimer had established a school of theoretical physics, and at the California Institute of Technology in Pasadena. Serber, like many other young physicists, was enthralled by Oppenheimer and decided to change course and head to Berkeley instead of Princeton for his NRC fellowship.

At Berkeley, Serber joined the coterie of young physicists who followed "Oppie," as he was known, from Berkeley to Caltech to Oppenheimer's New Mexico ranch and back to Berkeley again. As a member of Oppenheimer's entourage, too, Serber was drawn into left-wing causes in the late 1930s, though more of a sympathizer than an activist like his wife. He occasionally met Oppenheimer's friends from other areas in the university, including Haakon Chevalier, the novelist, French professor, and Communist Party member whose entanglements with Oppenheimer were a major part of the latter's downfall during his 1954 security clearance hearing. The Serbers, indeed, show up in Chevalier's melodramatic, thinly disguised roman à clef *The Man Who Would be God*: Robert as a short Jew with thick glasses who stutters but is one of the Oppenheimer character's "most brilliant students and associates," Charlotte as his "small and birdlike" wife who "was not really pretty" but "because of the way she handled herself she was as attractive as if she were." Serber, however, was one of the few members of Oppenheimer's retinue who was self-possessed enough not to imitate Oppenheimer's mannerisms, including the slight lisp, the loping walk, the pipe.

From 1936 to 1938 Serber performed his first synoptic service as Oppenheimer's chief research assistant. Oppenheimer typically had about eight to ten graduate students and half a dozen doctoral students, and once a day would collect them all together in his office. Oppenheimer would go around the room discussing each person's research and its problems in turn, and then depart. Serber would then go around the room himself, explaining to the often baffled students what Oppenheimer had just said. They were more comfortable discussing their problems with Serber than with the caustic and intimidating Oppenheimer.

One of Oppenheimer's talents was a keen sense for the key issues at the forefront of physics, and he would assign students to work on each. Already in 1934, therefore, Serber began working at the vanguard of issues of theoretical physics of the 1930s: self-energy, cosmic-ray theory, nuclear forces, and the nuclear cycle inside stars. In one of several important papers of this time on the self-energy of the electron, or the way that the electron interacts with itself and with the vacuum due to its electric field, Serber introduced the word "renormalize" into physics. In 1937 Serber and Oppenheimer coauthored a paper applying quantum electrodynamics to the understanding of cosmic-ray showers, which proposed that a new particle, the pi meson or pion recently proposed by Japanese theorist Hideki Yukawa, was the explanation for the "penetrating component" of such showers. In another paper on the subject, however, Oppenheimer and Serber were also the first to point out problems with this identification. Several of Serber's other seminal papers of the 1930s were on pion physics, nuclear forces, and nuclear reaction theory. Serber also examined the nuclear cycle inside stars and on stellar cores, and participated in the early discussions that culminated in the work by Oppenheimer and Hartland

Snyder predicting the existence of black holes, which is among the most important of Oppenheimer's contributions to physics.

In 1938 Serber was offered an assistant professorship at the University of Illinois, Urbana. His initial impulse was to stay at Berkeley with Oppenheimer, but I. I. Rabi intervened, persuading Serber that real jobs for Jewish students were rare, and that he should seize the opportunity and "cut the umbilical cord" to Oppenheimer. Serber gave in and moved to Urbana in September 1938.

Thanks in part to its chairman Wheeler Loomis, the Urbana Physics Department was an active place. And several young theorists in the Midwest organized a theoretical seminar that met monthly, alternating between Urbana, Bloomington, Lafayette, St. Louis, South Bend, and Evanston. Serber published very little during this time—one paper a year for the next few years—in part because he did not like writing; when he did publish, it was usually because he was pushed into it by Charlotte, I. I. Rabi, Oppenheimer, or someone else. Yet he continued to be enormously influential and widely consulted by experimenters and theorists alike.

Serber continued to visit Oppenheimer at the latter's ranch every summer. During the school year, Oppenheimer wrote Serber a letter every Sunday, relaying developments in Berkeley. In one of those letters, in January 1939, Serber first learned of the discovery of fission and of the possibility of nuclear explosions. And a few weeks after Pearl Harbor, in late December 1941, Oppenheimer dropped by Urbana to visit Serber. In a stroll in the cornfields beyond the town limits, Oppenheimer told Serber about the atomic bomb project, and asked him to come to Berkeley to be his assistant on it. It took a few months for Serber to disentangle himself from Urbana, but in April 1942 Robert and Charlotte packed their car and drove to Berkeley, where they lived in a small room above Oppenheimer's garage. Serber then performed his synthetic service a second time. He studied all the documents that Oppenheimer had collected that might be relevant to a project to build a fission bomb, including such topics as diffusion, critical mass, bomb design, and so forth, which he explained to the group Oppenheimer had brought together. And in July 1942 Serber integrated this information and explained what was known and what had to be determined to a meeting of theorists assembled by Oppenheimer that also included Hans Bethe, Felix Bloch, Stan Frankel, Emil Konopinski, Eldred Nelson, Edward Teller, Richard Tolman, and John Van Vleck. This was an important step in getting the Manhattan Project going.

In March 1943 the Los Alamos laboratory opened. Oppenheimer named Charlotte leader of the Library Division, the only female division leader at the laboratory. Oppenheimer asked Robert to head the group on diffusion theory in the theoretical division. Oppenheimer also asked Serber to give a series of talks summarizing the state of knowledge about the possibility of the still-theoretical bomb for the assembled scientists. In the talks Serber performed his synthetic service a third time: these talks were declassified in 1965 and were published in 1992 as *The Los Alamos Primer*. This series of talks was Serber's single most important contribution to the Manhattan Project, and a major factor in the speed with which the project was able to unfold. In his book *Lawrence and Oppenheimer*, Nuel Pharr Davis describes these lectures as follows:

> A lean, dark, inconspicuous wisp of a man, Serber hated dramatics. While talking, he stumbled continually over his words and swallowed impatiently as though he had dust from the mesa lodged in his throat but felt his subject too trivial to justify a sip of water. Nevertheless, he held his audience. "He

wasn't much of a speaker," says one of those present. "But for ammunition he had everything Oppenheimer's theoretical group had uncovered during the last year. He knew it all cold and that was all he cared about.

And Serber's performance inspired the following ditty from Teller:

Our desire for kno[w]ledge is most deeply stirred
When the statements of Serber can never be heard.
What, not heard at all?
No, not heard at all!
Very dimly seen
And not heard at all!

Remarkably, and due no doubt to Oppenheimer's influence and the urgency of the Manhattan Project, Serber worked for a year without a formal security clearance. The security investigators eventually caught up with the Serbers in 1943, and based on information they had collected—principally about Charlotte's family—they recommended that both be "removed from the [bomb] project." The recommendation was overridden. But this would not be the end of the Serbers' security woes.

After the successful test of the plutonium bomb at Alamogordo on July 16, 1945, Serber left Los Alamos as a member of the team that would assemble the bomb on Tinian Island in the South Pacific. The team members also included Norman Ramsey and Philip Morrison. Serber found that there was little that he could contribute as a theorist. However, one day he was approached by Col. Paul Tibbets, the commander of the 509th Composite Group, who was to fly the plane to drop the bomb on Hiroshima, and who was concerned about the effects of the blast on the plane. Tibbets drew a picture of the maneuver he planned to make after releasing the bomb; Serber did some calculating and told Tibbets exactly how long it would take the shock wave to reach the plane after the explosion and how much the pressure would be. He assured Tibbets that the plane would be safe. Serber was supposed to be onboard one of the planes that would fly the Nagasaki mission, operating the Fastax camera to record the blast but was put off after failing to have been issued a parachute—a disappointment about which the usually taciturn Serber could be passionate the rest of his life. Following the Japanese formal surrender, in September 1945, Serber was a member of the team sent to Hiroshima and Nagasaki to survey the bomb damage. One of his findings was that there was little lingering radiation due to the fact that the bomb had exploded high in the air.

On Serber's return, in fall 1945, Oppenheimer sought an appointment for him at Berkeley. In a letter to Berkeley's president Robert G. Sproul, Oppenheimer wrote, "Serber's living interest in the frontiers of physics, his profound insight into even the most difficult problems, his readiness to be of assistance to students and to colleagues engaged in an experimental attack on nuclear physics, all recommend him most highly as one of the most valuable theoretical physicists in the country today." But Oppenheimer was unable to land Serber a position at Berkeley, possibly because of anti-Semitism on the part of Physics Department chairman Raymond T. Birge. However, Oppenheimer was able to secure a position for Serber at the Berkeley Radiation Laboratory, directed by Ernest Lawrence, where Serber became head of the Theoretical Division. But Serber often stepped in as substitute teacher for Oppenheimer at Berkeley during the latter's increasingly frequent trips to Washington. In May 1947 when Oppenheimer left Berkeley to become director of the Institute for Advanced Study in Princeton, Serber fully took over Oppenheimer's teaching duties, which eventually earned him an appointment in the Physics Department.

Meanwhile, Serber was carrying out his synthetic service yet a fourth time, giving weekly lectures on the state of particle physics at Berkeley. A graduate student wrote them up and printed them as Rad Lab reports under the title *Serber Says* (1987). Two reports appeared—one on high-energy processes and nuclear forces, the second on mesons—and while a third, on nuclear physics in the 100 MeV region, was compiled it was never issued, even as a Rad Lab report. A mimeographed form was widely circulated in physics departments at the time, however, and Serber published a concise version as "Nuclear Reactions at High Energies" (1947). His research in nuclear physics included work on the pi-zero meson and on the nuclear optical model—jocularly known as the "cloudy crystal ball" model—in which neutron waves traversing the nucleus are described by an index of refraction in calculating absorption, diffraction, and total cross-sections. He also described, but did not publish, an influential account of nuclear forces that described their shape, or dependence on distance of separation. While Heisenberg had rejected the idea of a "repulsive core," or nuclear force that was repulsive at small distances and attractive at greater ones, Serber revitalized the idea to explain scattering data, and for a while it was known as the "Serber force." Following a press conference at Berkeley on the artificial production of mesons, a *Life* magazine photographer took a photograph of Serber that wound up in Edward Steichen's book *The Family of Man.*

In accelerator theory Serber worked with Don Kerst on the early development of the betatron; wrote "Orbits of Particles in the Racetrack" (1946), a study of beam stability in synchrotrons with straight sections; and was also the coauthor with seven others of a paper on the "Initial Performance of the 184-inch Cyclotron at the University of California" (1947). While studying the problem of producing external beams, Serber developed a mechanism for producing a high-energy neutron beam by stripping the protons off deuterons by colliding them with nuclei. Serber was a participant at the famous Shelter Island conference on elementary particle physics in 1947 on Shelter Island off Long Island, New York, and its two follow-up conferences in Pocono Manor, Pennsylvania, in 1948, and Oldstone, New York, in 1949.

Even after Los Alamos, security clearance problems continued to follow the Serbers. It was indeed a strange time in U.S. history, when obsessive concerns about security wound up damaging rather than strengthening the country's infrastructure. Despite Charlotte's clearance during the Manhattan Project, she was refused clearance at the Berkeley Radiation Laboratory in 1946, where she wanted to work as a librarian able to handle classified material. And the FBI wiretapped the Serbers and opened their mail from 1946 into 1948. In 1948 the Atomic Energy Commission threatened to remove Robert's clearance, on evidence mainly stemming from the leftist activities of Charlotte's family. On August 5, 1948, Robert faced a Personnel Security Board hearing into his "character, associations and loyalty." He passed, but as he wrote in his memoir, he "found the experience humiliating and frightening, and resented having been put through it."

The explosion of the first Soviet atomic bomb in 1949 helped to generate new concern over nuclear weapons. Serber was briefly involved in the dispute over development of the H-bomb, and was torn between his Berkeley boss Lawrence, who was enthusiastic about the idea, and his more cautious friend and mentor Oppenheimer. In 1950 the regents of the University of California reaffirmed their commitment to a requirement already in place that faculty and employees of the university sign an oath swearing allegiance to the United States, and began to fire those who refused. Serber was disturbed by this development, which led to a campus uproar and to the departure of several of his colleagues, but did not take the matter seriously enough to refuse and signed the necessary statement of loyalty. Growing antagonism between his friends Ernest Lawrence and Oppenheimer, however, seems to have contributed to Serber's decision to leave Berkeley for Columbia, where his old friend I. I. Rabi was located and which was in Oppenheimer's proximity. Security problems still followed Serber, however, and the FBI opened a new investigation of him in 1951. In 1953 security clearance problems resulted in the rejection by the Office of Naval Research of Serber's application for travel funds to attend a physics conference in Japan.

At Columbia, Serber initially worked on atomic beam theory for Rabi, which he did not publish until much later. But he was soon performing his synthetic service yet again, at Brookhaven National Laboratory on Long Island, where he spent one day a week and occasional summers for the next 20 years. He was the most influential theorist at that laboratory for over a decade. Serber worked on several topics, including strong coupling, but his principal influence continued to be through his advice and consulting. This influence resulted in his making several assists in key discoveries of particle physics of that era, as reflected in mentions of him in the footnotes of papers such as the Pais-Piccioni paper on the regeneration effect, and the Landé, Lederman, and Chinowsky paper on the discovery of the K-long particle.

Quantum field theory was unfashionable for a while in the late 1950s and early 1960s, but Serber, undeterred, continued to develop it. This led to one of his most famous assisted discoveries—of quarks—by fellow quantum field theorist Murray Gell-Mann. In 1963 Gell-Mann came to Columbia to give a talk. In preparation Serber examined the symmetry group known as SU(3) and found an irreducible representation of it that would involve a particle that could exist in three states. At lunch before the talk Serber outlined the discovery to Gell-Mann, who then worked out implications of the idea, calling the three-state particles “quarks.”

Oppenheimer died in February 1967, and Serber was one of the speakers at the memorial service. That May came a second personal tragedy when Charlotte, who had become severely depressed after being diagnosed with Parkinson’s disease, committed suicide. Within a few years the two widowed spouses, Serber and Kitty, moved in together.

Serber continued his advisory work at the various national laboratories, which now included weekly trips to the newly established Fermilab outside Chicago, to deliver lectures on the state of particle physics. However, he turned down an invitation to join JASON, the summer consulting group for the Institute for Defense Analyses. As was typical of Serber, he had no firm ideological reason for doing so, and the decision was based partly on his annoyance at his past security troubles and partly on his opposition to the Vietnam War. In 1969 Serber became vice president elect of the American Physical Society, meaning that he automatically became vice president in 1970 and president in 1971. Now he had a harder time avoiding Vietnam-era political ferment, and at various APS meetings found himself in the unexpected position of representing the establishment in the face of protests—with which he was not unsympathetic—against the Vietnam War, against the Nixon Administration, and against William Shockley. Politics was even affecting scientific awards. In 1971 Serber was on a committee that recommended Steven Weinberg for the 1972 Oppenheimer Prize, but the nomination ran into a snag because of Edward Teller’s vociferous opposition to Weinberg, thanks to the latter’s public stance against Nixon’s antiballistic missile system. In an awkward compromise the committee awarded the 1972

Oppenheimer Prize to Serber—who considered refusing in protest and accepted only to avoid the embarrassment that scandal would bring to the prize—with Weinberg the winner the following year.

In 1972 Serber stepped down as APS president: his presidential address was entitled simply "Serber Says: Volume III." A few months later he began a yearlong sabbatical, planning to spend most of it on a trans-Pacific sailing trip to Japan with Kitty. During a preliminary part of the trip, in the Caribbean, Kitty fell ill with what turned out to be a severe intestinal infection. They sailed for Panama City, where Kitty died on October 27. Serber and Kitty's daughter Toni Oppenheimer scattered her ashes off Carvel Rock in St. John, where Kitty herself had scattered Oppenheimer's ashes.

After his sabbatical, Serber went back to teaching and became chair of the Columbia Physics Department in 1975 until the time of his mandatory retirement in 1978. In these years he published one paper, "A Simple Nuclear Model," containing an easily understandable nuclear model for students. In 1979 Serber married Fiona St. Clair, a fabric designer whose family came from St. John. Fiona had a son, Zachariah, by a previous marriage, and Serber and Fiona had a child, William, in November 1980.

In 1983 a time of worldwide nuclear disarmament protests, Serber again found himself out of step with mainstream opinion. Zach was in the fourth grade, and his teachers asked Serber to speak in the school auditorium about the Manhattan Project. Most of the audience, he discovered, had been reared on the view that working on such a project was a sin. "They came from a society," Serber complained in his memoir, "whose notion of war was formed by Korea and Vietnam and remembered nothing of the realities of an all-out war like World War II."

Robert Serber was a man of great integrity who thought deeply and attentively about physics and about the world around him. He preferred withholding his thoughts and feelings to expressing them carelessly, which could sometimes mislead those who did not know him into thinking him withholding or insensitive. This was most striking in his reticence to discuss publicly his moral thinking about the Manhattan Project. Serber had no hesitations about joining the project, and no regrets about it afterward. Modern sensibilities are more attuned to Oppenheimer's breast beating—to his remarks about how, thanks to the project, "physicists have known sin"—and seem to assume that an action cannot be ethical unless accompanied by full disclosure of feelings and motives. Serber preferred to keep his thoughts to himself, a stance that ought to motivate those who would criticize him at least to examine their assumptions.

During the 1980s, Serber published several articles about physics developments that he had witnessed, as well as material from his nuclear physics course in book form, *Serber Says: About Nuclear Physics* (1987). In 1992 he published an annotated version of his Los Alamos lectures, *The Los Alamos Primer*. In 1994 at the age of 85, Serber was asked to deliver the Pegram lectures at Brookhaven National Laboratory. The prestigious lecture series was established in 1959 "to provide an opportunity for distinguished scholars to examine the interaction between science and other aspects of our culture and society." Serber chose to speak about this wartime work as well as his research immediately after the war at Berkeley, Columbia, and Brookhaven. The texts of Pegram lectures are ordinarily submitted to Columbia University Press for publication, and Serber was asked for additional material. By this time, however, Serber was virtually blind, but he demonstrated his synthetic ability on one final occasion as he used a magnifying glass to read over the manuscript, deciphering one letter at a time on the computer (large-print type would not work, as he could not see where to place his pen for corrections), keeping the entire manuscript in his head all the while.

A few days after going over the final draft of what would be published as *Peace and War: Reminiscences of a Life on the Frontiers of Science* (1998), Serber entered the hospital for surgery to remove a brain tumor. He never fully recovered from the operation, and died on June 1, 1997, at the age of 88.

NOTE

1. B. J. Bernstein. Interpreting the elusive Robert Serber: What Serber says and what Serber does not explicitly say. *Stud. Hist. Phil. Mod. Phys.* 32(3) (2001):443-486.

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