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HENRY HERMAN BARSCHALL
1915–1997

A Biographical Memoir by

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HENRY HERMAN BARSCHALL, known to friends and family as Heinz, was born April 29, 1915, in Berlin. Barschall's studies of the nuclear interactions of fast neutrons, described in about 100 papers, uncovered important characteristics of the nucleus. His seminal work on physics journals, in general, and his long editorship of *Physical Review C* (nuclear physics), in particular, placed his imprint on physics publications; his work on the design of neutron generators for medical purposes and his studies of neutron interactions in biology constituted a significant contribution to medical physics; and his administrative work for the Physics Section of the National Academy of Sciences and, especially, for the American Physical Society and the American Institute of Physics, led to an unprecedented memorial session of the American Physical Society after his death. And education was always central to his interests. He guided forty-one graduate students through to their Ph.D.s, and the introductory, intermediate, and graduate courses he taught over his forty-one years as a professor at the University of Wisconsin were models of pedagogical clarity.

Barschall's father was a patent attorney who received a Ph.D. in chemistry after studying with Nobel Laureates Emil Fischer and Fritz Haber; Max Planck was a friend of the family. Heinz recalled the excitement, though he was only seven years old, when his father's cousin Otto Meyerhof was awarded the Nobel Prize in medicine. Berlin was a vibrant artistic and scientific center in the 1920s and Barschall recalled attending popular lectures by Einstein, Planck, Hahn, and Debye while in his teens; and he "always listened" to the regularly scheduled radio program of the philosopher of science Hans Reichenbach.

Barschall's graduation from high school in 1933, the only student to graduate with distinction, coincided with Hitler's assumption of power. However, with the political situation as it was, he did not attend the graduation exercises. Though he was raised in the family tradition as a Lutheran, many of his forbears—of whom he knew little—were Jewish, and Heinz found himself proscribed under the Nazi racial laws and unable to continue at the University of Berlin, where he had begun studies. After spending much of the summer of 1933 in England, he went to Paris. There Edmond Bauer, professor of physics at the Collège de France, an old friend of the Barschall family, received him as if he were a member of his family.

In Paris, Heinz studied physics and mathematics at the Sorbonne. While 1933 was an exciting time in French physics, with the discovery of artificial radioactivity and early work with neutrons and positrons, he found the instruction "terrible." With some relaxation of the German situation, he was able to resume his studies at Berlin in the spring of 1934. There he took courses at the university and at the Technical University. At the university, von Laue was in charge of theoretical physics, though he refused to lecture for reasons related to his opposition to the Nazi regime, and Marianus Czerny taught "an excellent experimental physics laboratory." At the Technical University Heinz studied experimental physics under Gustav Hertz and electromagnetic theory under Richard Becker. In general, he found the instruction "far better than at the Sorbonne." Outside of formal classes, Barschall studied the theoretical physics text of Georg Joos, along with fellow student Werner Stein, a convinced anti-Nazi who "made a point of being friendly [with Heinz]" and came to the Barschall home once a week to work with Heinz. After the war in which Stein, though with a Ph.D., was drafted and served on the Russian front, he became a professor at the University of Berlin and the senator (secretary) for art and science in the government. When Barschall visited Berlin after the war, Stein put his official limousine, with driver, at Heinz's service.

In 1936, when Barschall was to find a major professor, the discriminatory procedures had consequences again. (Barschall's Berlin 1934 Studienbuch marking him as Jewish is prominently displayed at the U.S. Holocaust Museum in Washington.) Many of the professors feared to take him on. He called on Lise Meitner, but unprotected by her Lutheran religion from the discriminatory laws herself and counseled by her colleague Otto Hahn to avoid risks, she expressed her regrets that she could not take him as a research student. Heinz spoke of seeing her at a conference in Birmingham twenty years later, where she immediately recognized him and recalled the conversation.

With the problem of finding a professor unresolved and at the suggestion of his aunt, Heinz called on Max Planck at his home. Planck was long retired, but he was still editor of the *Annalen der Physik*, along with Eduard Grüneisen. Planck gave Heinz a note to Grüneisen, a physics professor at Marburg. Grüneisen, who Heinz described as "an honorable and courageous man" immediately agreed to accept him as a student and Heinz went to Marburg in the fall of 1936. After World War II, when conditions in Germany were very difficult, Barschall was able to help Grüneisen and

Stein with CARE packages, which provided food for their families.

Heinz writes that "the physics laboratory at Marburg was at that time an oasis where Hitler's existence was barely noticeable—and all of the physics students were friendly." (In 1982 Barschall was awarded an honorary degree by Marburg.) However, he realized that he had to leave Germany, but to where? He wrote a childhood friend, Gisbert Ruge, whose family had sent him to Princeton as an undergraduate, for advice and got back a ten-page letter with detailed financial, social, and administrative information. Ruge had done exhaustive research with his principle source of information a fellow undergraduate from Germany then unknown to Heinz, Wolfgang Panofsky.

Panofsky suggested that Barschall also consult Rudolf Ladenburg, a Princeton physics professor. Heinz sought the help of Otto Meyerhof, who had been a professor along with Ladenburg at the Kaiser Wilhelm Institute in Berlin. Contacted by Meyerhof, Ladenburg arranged for Heinz to come to Princeton as a graduate student in the fall of 1937, although Heinz did not then, or ever, have a bachelor's degree.

At Princeton Barschall did his thesis research under Ladenburg, "who was kind and helpful," but Barschall felt he learned more from Morton Kanner and John Wheeler. Kanner was a fellow graduate student, who Heinz considered a brilliant experimentalist (Kanner died of cancer only a few years later), and Heinz especially valued the theoretical instruction from Wheeler. Wheeler later helped Barschall personally by making arrangements for his parents to come to the United States in 1943 from England, where they had lived since 1939 after leaving Germany. Heinz also spoke of his appreciation for the help he was given by Eugene Wigner and Louis Turner. Faced with a tricky problem of correcting some of his measurements for the geometric acceptance of his apparatus, he was told to ask for help from a bright young theoretical student from New York. According to Heinz, his fellow student looked at Heinz's carefully defined problem in a rather disinterested manner and mumbled something to the effect that he would look at it if he had a chance. A few days later the student, Richard Feynman, presented Heinz with a carefully written, elegant solution to his problem.

In 1939, a little more than a year after Barschall had begun work at Princeton, Niels Bohr arrived with the news of the discovery of fission and urged Ladenburg and his colleagues to conduct some experiments on the new fission process using fast neutrons. Kanner and Barschall had been working with 2.5-MeV neutrons produced through the $D + D \rightarrow {}^3He + n$ reaction by deuterons accelerated to 400 keV by a transformer-rectifier set striking a D^2O ice target. Interrupting his thesis research, in a few days work with Ladenburg, Kanner, and Van Voorhis, Barschall demonstrated the fission of uranium from the interaction of 2.5-MeV neutrons and measured the cross-section and energy yield. While slow neutron fission proceeded through interactions with the recently discovered rare isotope ${}^{235}U$, they demonstrated that the fast neutron fission was dominated by neutron interactions with the primary isotope ${}^{238}U$.

Half a year later after further measurements of fast neutron fission, Heinz resumed his thesis work with Kanner on the scattering of 2.5-MeV neutrons by the lightest nuclei. In 1940 John Wheeler and Barschall showed that the measurements Heinz made with Kanner of the angular distribution of neutrons scattered from helium showed conclusively that spin-orbit nuclear forces were very strong—much stronger than anyone had then believed. Both the experimental results and the analysis can now be seen to be valid and convincing; but, in 1940 the special experimental techniques developed by Barschall and Kanner were new—and perhaps too clever. Barschall had been able to show that the distribution of pulse-heights in their helium gas ionization chamber produced by the recoils of the helium nuclei struck by the neutrons, corresponded, with only a transformation of units, to the neutron scattering angular distribution in the center of mass system. The partial wave analysis introduced by Wheeler to analyze the data, commonplace a few decades later, was not then understood by all. With those barriers and the coming war effort, which quickly absorbed the energies of all physicists, their paper in the *Physical Review* reporting their discovery of large spin-orbit coupling in nuclei attracted little attention, and that large coupling had to be rediscovered nearly a decade later, mainly by Maria Mayer and Hans Jensen, where it was basic to their shell model of nuclei.

Barschall received his degree at the end of the summer of 1940 and was asked to stay at Princeton for a year as an instructor. He enjoyed the teaching, but he still had to find a job at the end of the school year. In 1941 there were few employment opportunities in physics and Heinz considered himself fortunate to be able to accept the offer of an instructorship at the University of Kansas by J. D. Stranathan, chairman of the Physics Department. In the course of writing a modern physics text, Stranathan had been impressed by Barschall's paper on fission. The salary was $1,850 for the year, a sum Heinz considered "quite generous," and he was encouraged to conduct research.

Shortly after Barschall began teaching at Kansas in the fall of 1941, the United States entered World War II. Although he wanted to join the war effort, he was classified formally as an enemy alien and confined by law to the city limits of Lawrence, Kansas. But physicists were uncommon then and sought after, and physicists who understood the techniques of fast neutron research were singular indeed, and invaluable. Consequently, with the aid of high-level intervention, Barschall was naturalized in 1943—when he changed his name legally to Henry Herman from Heinrich Hermann. But even higher-level intervention was required to obtain Barschall's release from the University of Kansas. General Groves, the military commander over Los Alamos and the Manhattan bomb project, arranged for the secretary of war to intervene directly. Groves told Barschall later that he was only the second person for whom such an intervention was needed (the other was Norman Ramsey).

At Los Alamos, Heinz continued the work he had began at Princeton studying the interactions of fast neutrons, but with far superior facilities. The electrostatic accelerators that Ray Herb had built at the University of Wisconsin and had moved to Los Alamos were especially important. At that time "fast" roughly meant energies greater than a few keV up to a few MeV, the maximum energies easily achievable at that time, while "slow" was applied to neutrons with lower energies, especially with energies spanning the thermal range. Slow neutron effects were important in nuclear reactors, where the neutrons were thermalized with graphite or heavy water, but the interactions of the fast neutrons, emitted in the fission process with energies in the range of an MeV, were crucially important in nuclear explosives, hence the critical importance of Barschall's work on fast neutrons.

An elected town council facilitated the non-technical aspects of the interaction of the largely civilian staff and the military. During the exceptionally cold winter of 1945-46 the pipeline that brought water from the mountains behind Los Alamos froze and the only available water was supplied by gasoline tank trucks, which brought water up from the Rio Grande River in the valley. With too little water, and that heavily chlorinated and contaminated by gasoline residues, living in the town became very difficult. While the military management recognized the problem, the solution was low on their priority list and they were not much interested in civilian complaints. So the chairman of the town council, the seemingly diffident, newly naturalized, young (not yet thirty) Heinz Barschall, arranged to meet with the military authorities to persuade them to find a more effective response. Finally, he met with the tough, hard driving, imperious General Groves to present the community's case. Groves, no doubt, thought he could overwhelm the young man and blustered and threatened. But Heinz, always cool and logical, and obdurate as always, when he felt that he was right, was immovable. The stalemate was soon ended when nature and sunshine released the grip of the cold on the pipeline.

After the war, drawn by the possibility of working further with Ray Herb's remarkable electrostatic generators and interested in teaching and working with graduate students, Barschall accepted an offer of a position at the University of Wisconsin. There, with a cohort of graduate students, he commenced a program of measurements of neutron cross-sections of different elements as a function of energy, which demonstrated the existence of broad, discrete resonances in the total cross-section in elements as heavy as lead. Such resonance structures, indicating that beyond the neutron binding energy the energy levels of even some heavy nuclei were widely spaced, were contrary to the generally accepted liquid-drop model of Bohr and Wheeler. Especially for light nuclei the spin and parity of the excited state was often defined by the height and shape of the total cross-section resonance. Thus, the experiments showed that the states were always defined by their total angular momentum and parity, indicating that spin-orbit and spin-spin forces were strong enough to remove all dynamic degeneracies. Worth Seagondollar, the first of forty-one students to receive a Ph.D. over the next thirty years with Heinz, obtained his degree in 1948, writing his thesis on his contribution to this program.

At about this time Viki Weiskopf, with Herman Feshbach, calculated the effect of the many energy levels—and thus many narrow resonances—expected from the then accepted models of nuclei on the total neutron cross-sections of nuclei averaged over a wide energy band. This theory predicted cross-sections that increased monotonically with atomic number and decreased monotonically with neutron energy. The cross-sections measured by Barschall and his students showed a more complex structure. With his students with whom he worked so closely, Heinz commenced a systematic study of the total neutron cross-sections of nuclei of different atomic number with resolutions that averaged over narrow resonances. He noticed that there were unexpected regularities in those cross-sections that seemed to vary systematically with atomic number. To gain a proper insight into this three-dimensional system, Barschall made cardboard cutouts of the cross-section versus energy of the different nuclei and stacked them up in order of their atomic number, with appropriate spacers for the unmeasured regions—regions that became smaller when Dan Miller measured a large set for his thesis.

It seemed clear to Heinz that the pattern indicated an optical effect and he tried to fit the data with an optical model, where the nuclei acted as simple square wells—clear crystal balls with an index of refraction representing the interaction strength. Such behavior was quite unexpected at a time when the liquid-drop model of nuclei—with very short nucleon mean free-paths—was still generally accepted. While Heinz's clear crystal ball models showed qualitative similarities to the data, the peaks and valleys of his models were much too strong. He enlisted some of the graduate students in his efforts, but they couldn't help. He realized that the too-strong theoretical peaks could be damped by absorption, but at energies below 1 MeV—where the data was most impressive—he knew, experimentally, that elastic scattering dominated and that absorptive processes were negligible.

Herman Feshbach, MIT graduate student Charlie Porter, and Viki Weiskopf solved the problem elegantly by including absorption—to generate a "cloudy crystal ball." Aside from their calculational competence, they understood that the narrow elastic scattering resonances represented an effective absorption. The broad energy averaging that Barschall employed meant that he was looking at complementarily short time scales, while the narrow resonances represented states that were long lived and incoherent with the nearly instantaneous scattering of the neutrons from the nucleus as a whole.

While it took the talents of superb theoretical physicists like Feshbach, Porter, and Weiskopf to properly understand Barschall's data in terms of nuclei that acted like cloudy crystal balls, it was Heinz who first recognized that the patterns must be generated by an optical process, and he pushed the program that generated the data that finally led to the correct picture.

The cloudy crystal ball, like the shell model derived at about the same time, showed that the mean free-path of nucleons in nuclear matter was far greater than that set by the conventional wisdom of that time. When Barschall was honored with the first award of the T. W. Bonner Prize in 1965 for exceptional work in nuclear physics, the citation emphasized his work that led to the optical model of the nucleus. That work was again cited when he was elected to membership in the National Academy of Sciences in 1972.

Barschall wrote later, "From 1946 to 1970 our group at Wisconsin investigated all aspects of the interaction of MeV neutrons with nuclei." The "all" included measurements of the angular distributions and polarizations of the neutrons scattered from nuclei, their absorption cross-sections, and further total cross-sections measured with better resolutions at the high energies that became available. The angular distribution and polarization measurements on heavy nuclei further defined the optical model; the same measurements on light nuclei established the neutron-proton scattering length fundamental to nuclear forces and through neutron-helium scattering measurements finished the seminal study of spin-orbit forces he began at Princeton as a graduate student.

Any historical study of Barschall's program in nuclear physics is complicated by the omission of his name on many papers, some of them relatively important. He felt strongly that his name should be only on papers in which he had played a major role in the conduct of the experiment—that the experiment was a part of a program that he had designed and directed was insufficient in itself for him to be listed as an author. This generosity was sometimes carried to an extreme. In the spring of 1949 Barschall and three relatively inexperienced graduate students were measuring the cross-sections of some light nuclei that Barschall had selected. When he left for a few days to attend the Washington meeting of the American Physical Society in the middle of a data-taking run, he left the students—with some trepidation—directions for the rather straight-forward further data-taking that had been scheduled. While Heinz was absent, the students measured the cross-section of sulfur and found an interference effect that makes sulfur almost completely transparent to 88 keV neutrons. When the students wrote a short paper on the new and intriguing result, Barschall refused to put his name on the paper. "You did it," he said. "I wasn't there."

During the decade after moving to Wisconsin, Barschall spent most summers at Los Alamos—and in 1951-52 he took leave from Wisconsin and spent the whole year there. During these visits, he worked on the laboratory's nuclear physics programs, often with one of his students from Wisconsin. In the course of these periods at Los Alamos, Heinz met Eleanor Folsom, who taught school there. Eleanor and Heinz were married in 1955. Eleanor was also from a family with academic and scientific connections; a close relative Dickenson W. Richards, Jr., was awarded a Nobel Prize in medicine in 1956.

Barschall recalls that in a physics laboratory course he attended at the University of Berlin in 1935, the teacher, the eminent spectroscopist Marianus Czerny, told the students that German physics journals were no longer predominant and that physicists had to read *Physical Review* to learn what was going on in physics. Thirty-five years later Barschall, as the first part-time "external" editor of *Physical Review C*, began policies that regained the traditional dominance of that journal as the publication of choice in nuclear physics. Most of those policies—and the use of eminent external editors tied closely to research—were eventually adopted by the other sections of the journal. After serving for fifteen years as editor of that journal, Barschall was succeeded by a former student, Sam Austin.

After his work as editor, Heinz served on key steering committees of the American Physical Society and American Institute of Physics, where he worked to introduce electronic publishing into the publication procedure. As chair of the library committee of the University of Wisconsin Physics

Department, he became aware that libraries could no longer afford the increasing cost of research journals. He decided to investigate journal pricing policies, evaluating the cost-per-word of library subscriptions to the various physical journals, and in 1986 published an article on the subject in *Physics Today*. In later work he included an impact factor that measured the degree to which articles in the journal were cited in subsequent literature. By and large, this work showed that the journals published by the eleemosynary professional organizations were much less expensive than those put out by commercial publishers. In 1990 Barschall was presented with a special citation by the Association of Research Libraries with special note to his work on periodical costs. But, that work led to litigation, instituted in the United States and Europe, directed towards the American Institute of Physics, the American Physical Society, and Barschall personally by a disgruntled commercial publisher. Nearly a decade later, with appeals and new filings, the litigation was continuing, although the physical societies had won nearly everywhere. These law suits, which occupied a significant part of Barschall's time after 1989, irritated Heinz, but he found a certain diversion in the proceedings and even some enjoyment in his fight for what he considered a just cause.

At about 3:00 a.m. on August 24, 1970, Barschall was awakened at his home, some two miles from the University of Wisconsin campus, by what he thought was thunder. A few minutes later, he received a telephone call telling him that his laboratory had been bombed. Knowing that one of his graduate students, David Schuster from South Africa, and an undergraduate assistant were working that night on an experiment, Heinz rushed to the scene of the bombing. There he was informed that Robert Fassnacht, a research associate in low-temperature physics had been found dead, but the undergraduate was safe. Heinz knew that Schuster must have been near the 6-MeV electrostatic generator that he was operating while taking data, and he started down the debris-covered stairs to the accelerator laboratory in the heavily damaged basement. The firemen restrained him because they considered it too dangerous to go down there, and they did not believe anyone could be alive in such wreckage. Heinz pushed them aside and was finally stopped only by the promise of the firemen themselves to go down into the basement. When they did, they found Schuster severely injured but alive. It then took the combined efforts of several fire departments to dig him out.

Campus radicals intent on damaging the Army-supported Mathematics Research Center, which was located on the upper floors of the building that housed physics laboratories, had set off a ton of explosives in a truck driven to a position adjacent to Barschall's laboratory. His research records, nuclear samples accumulated over twenty years, and much equipment was lost. The mathematical institute lost one day of work.

Dispirited by the bombing, the death of the researcher, and the injuries to his student, upset over what he felt was insensitivity and insufficient help from the physics department and the university administration, disliking the increasing effort required to obtain financial support for his research, unconvinced of the usefulness of training additional graduate students, Barschall decided not to rebuild his laboratories and he never again worked in nuclear physics research.

After arranging for completion of theses by the five graduate students who wanted to continue, Barschall left Wisconsin and moved with his family to Livermore in the summer of 1971. There he began to work at the Lawrence Livermore Laboratory on the development of intense sources of high-energy neutrons for materials testing and medical uses. While he was happy at Livermore, his wife Eleanor and the children Anne and Peter missed Madison, where Eleanor was active in public affairs. With the promise of strong support from the department and the university, Heinz returned to Madison in 1973 with a joint appointment in the Department of Nuclear Engineering and the Physics Department.

After his return, most of Barschall's research efforts were in medical physics directed towards the application of neutrons to cancer therapy. At that time he also accepted a joint appointment in the Department of Medical Physics. The Wisconsin medical physics department, founded by John Cameron, who had received his Ph.D. in nuclear physics at Wisconsin in the early 1950s, was the first such department in the country. At Livermore, Heinz had worked on studies of the effects of neutrons on mice and studied the neutron spectra from cyclotron sources used in therapy. Later, with fellow members of the medical physics faculty, he worked on the development of neutron dose standards for therapy. A member of the American Association of Physicists in Medicine, he chaired in 1984-86 a National Academy of Sciences committee concerned with the election of medical physicists to the Academy.

Aside from his work on publications, Barschall, who could be relied on to handle almost any matter wisely, competently, and completely, was called on by the academic and scientific communities for many tasks. At the University of Wisconsin, he served, as he wrote light-heartedly, on "many committees ranging from parking to tenure" and he served the Physics Department in almost every capacity, including the chairmanship. With his one-time colleague at Wisconsin, Robert Sachs, he developed the procedures still largely in place for nominations by the Physics Section of the National Academy of Sciences over a period in which he chaired that section; he also served a term as chairman of the Awards Committee. But the American Physical Society constituted the main arena of his service. Aside from his very important work in publications, he played a significant role in the establishment of the Nuclear Physics Division in 1966 and served as its second chairman in 1967.

Perhaps Barschall's most characteristic service to the American Physical Society was, on the surface, the least characteristic. The Forum on Physics and Society was established as a special division of the society in 1972. Somewhat unfairly, the forum was marginalized to some extent by the distrust of the more conservative members of the American Physical Society. In 1988 Barschall considered by everyone to be absolutely responsible and responsibly conservative, volunteered to serve as the secretary-treasurer of the forum. With a longer tenure than the chairman, the secretary-treasurer is the de facto dominant figure in the divisions. During the five years he served in that post, Barschall worked to revise the constitution of the forum and succeeded in helping it gain a broader acceptance in the American Physical Society, where it has played an increasingly important role in the direction of the society.

Somewhat reserved, perhaps even austere to those who did not know him well, Barschall possessed a basic integrity, was loyal to his friends and colleagues, and displayed a generosity of spirit that led to his being held with exceptional loyalty and affection by those colleagues and friends. In particular, he was a public-spirited man with an idealism clothed in pragmatism, which led to little in the way of rhetoric and much in the way of accomplishment. His peers recognized this; chosen "mayor" of Los Alamos before he was thirty, called on by the physics community for many tasks, Heinz Barschall was known as someone who could get a job done and done well.

The loyalty of those who worked for and with Heinz was repaid with interest by Heinz. He worked sedulously to see that his students' careers progressed satisfactorily. In return, his students held him in affection and respect. For many years, his former graduate students, the Barschall alumni, met at dinner with Heinz annually at the Washington meeting of the American Physical Society. There were special celebrations on his sixtieth and seventy-fifth birthdays. He will be remembered with affection and respect, and with the gratitude of the physics community for his contributions to physics and to that community.

He is survived by his wife Eleanor, son Peter H. Barschall, daughter Anne E. Barschall, and two grandchildren.

IN WRITING THIS MEMOIR, we drew extensively on biographical material assembled by H. H. Barschall for the Academy's files and for his family and friends.

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