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KARL FERDINAND HERZFELD
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A Biographical Memoir by

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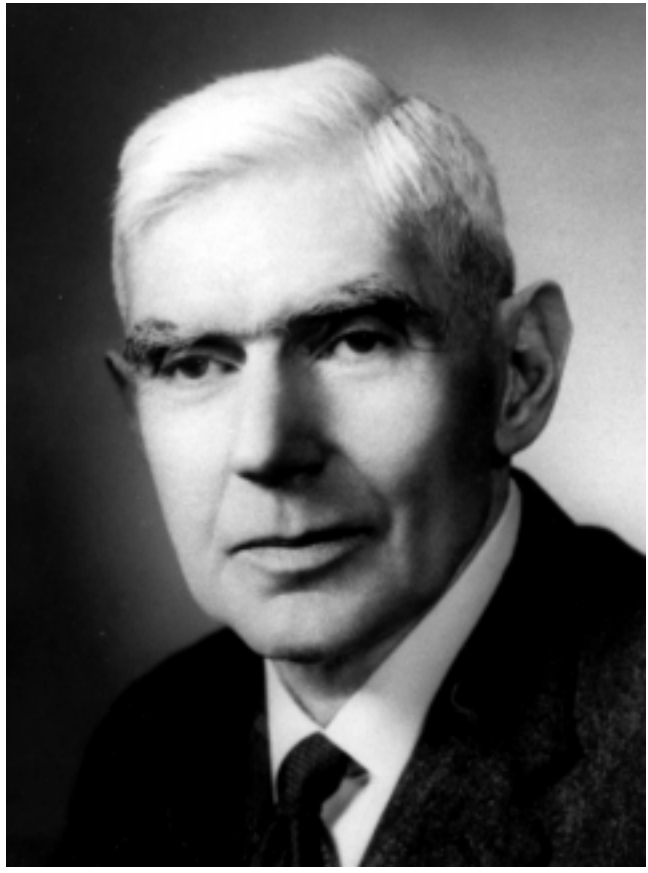

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Karl F. Herzfeld

KARL FERDINAND HERZFELD

February 24, 1892–June 3, 1978

BY JOSEPH F. MULLIGAN

KARL F. HERZFELD, BORN in Vienna, Austria, studied at the university there and at the universities in Zurich and Göttingen and took courses at the ETH (Technical Institute) in Zurich before receiving his Ph.D. from the University of Vienna in 1914. In 1925, after four years in the Austro-Hungarian Army during World War I and five years as *Privatdozent* in Munich with Professors Arnold Sommerfeld and Kasimir Fajans, he was named extraordinary professor of theoretical physics at Munich University. A year later he accepted a visiting professorship in the United States at Johns Hopkins University in Baltimore, Maryland. This visiting position developed into a regular faculty appointment at Johns Hopkins, which he held until 1936. Herzfeld then moved to Catholic University of America in Washington, D.C., where he remained until his death in 1978.

As physics chairman at Catholic University until 1961, Herzfeld built a small teaching-oriented department into a strong research department that achieved national renown for its programs in statistical mechanics, ultrasonics, and theoretical research on the structure of molecules, gases, liquids, and solids. During his career Herzfeld published about 140 research papers on physics and chemistry, wrote

two important books: *Kinetische Theorie der Wärme* (1925), and (with T. Litovitz) *Absorption and Dispersion of Ultrasonic Waves* (1959), and made major contributions to Felix Klein's *Encyklopädie der Mathematischen Wissenschaften*, to the *Handbuch der Physik*, and to the *Handbuch der Experimental Physik* on a variety of topics relating to physicochemical properties of matter.

John A. Wheeler, whose doctoral dissertation Herzfeld had directed at Johns Hopkins, summed up Herzfeld's career as follows: "No one who came so early [1926] from Europe to America continued longer to give so richly to this country out of the great European tradition of theoretical physics."[1]

Karl Ferdinand Herzfeld was born in 1892 in the Vienna of the Hapsburgs and the Austro-Hungarian Empire. He came from a prominent, recently assimilated Jewish family. His father was a physician with an extensive practice and an associate professor of obstetrics and gynecology at the University of Vienna; his mother, nee Camilla Herzog, was the daughter of a newspaper publisher and sister of a well-known organic chemist, R. O. Herzog. Karl's grandfather had begun the assimilation of his family into the predominantly Christian culture in Vienna. Karl's parents were both baptized, as was Karl himself soon after birth; he remained a dedicated Catholic for the rest of his life.

The Herzfeld family had a strong sense of duty to members of the family and to the larger Viennese society of which they were part. His parents also had a strong commitment to serving that society as true professionals. This parental commitment throws much light on Karl's extraordinary dedication to duty throughout his entire life. These were the values of the Herzfeld family—values that were constantly in evidence in Karl's later career.

When he was 10, his parents enrolled Karl in a private *Gymnasium* run by the Benedictine Order of the Roman

Catholic Church. It was called the *Schottengymnasium*, since the Benedictines who had founded the school came from Scotland. Karl continued his education there until he was 18. He always retained fond memories of the rigorous classical education, the thorough training in science and mathematics, and the great appreciation for intellectual activity he acquired during these formative years.

In 1910 Herzfeld enrolled in the University of Vienna to study physics and chemistry. His mentor in physics was Friedrich Hasenöhrl (1874-1915), who had taken the place of Ludwig Boltzmann as head of the Theoretical Physics Institute in Vienna following Boltzmann's lamentable suicide in 1906. Hasenöhrl was well known in Vienna for having proved in 1904 the validity of the equation $E=mc^2$ for cavity radiation, just a year before Einstein established its general validity.

Due to the tradition established by Boltzmann, Vienna was considered the outstanding university in statistical physics in all of Europe. Although Herzfeld did take a course from Hasenöhrl that included thermodynamics and statistics, he always said that he had learned little statistical physics in Vienna, and had mastered the subject only during the year he spent in Zurich, where he met Otto Stern (1888-1969). (Stern is better known today as an experimentalist, who received the 1943 Nobel Prize in physics for his work on molecular beams.) In 1912 Stern was Einstein's assistant at the Technische Hochschule in Zurich. Einstein was lecturing there on thermodynamics and statistical mechanics, but all his research time was devoted to general relativity. Herzfeld was not interested in this subject, and his interactions with Einstein were infrequent and disappointing. But he did find a kindred soul in Stern, as indicated in his statement: "I profited enormously from contact with him [Stern] and

acquired from his conversations whatever deeper understanding of thermodynamics I have."[2]

In 1914 Herzfeld returned to Vienna. He successfully defended his doctoral dissertation, which applied statistical mechanics to a gas of free electrons as a model for a theory of metals (1913). By the time he completed his physics degree in 1914 he already had six research papers to his credit. One of these was an attempt to derive a model for the hydrogen atom (1912), published just before Bohr's famous 1913 paper. Herzfeld used a technique similar to that of Bohr to quantize the allowed energy levels for a modified Thomson atom, leading to the quantization of the radii of the electron orbits. He had failed to grasp the essential point, however, that it was the energy differences between the quantized energy levels that were required to find agreement with the experimental Balmer spectrum. Though he had missed this crucial feature of Bohr's theory, Herzfeld had clearly demonstrated his ability to do high-level research in a new field.

Herzfeld received his Ph.D. in July 1914, and he immediately signed up for one year of service in the Austro-Hungarian Army. When the First World War broke out a few months later, however, he served with distinction for three more years as an officer in a heavy-artillery battery on the Russian, Serbian, and Italian fronts. Later Herzfeld looked back on his military service without regret: "I had the luck that I could do some work even during the war, being a theoretical physicist. . . . I was an observer in the mountains, sitting in a hut. You could go out six or eight times a day for twenty minutes. And either you play cards or you are luckier and write a paper."[3]

Herzfeld wrote six papers while in military service from 1914 to 1918. All involved the application of statistical methods to problems in physics and chemistry. By the end of the

war he had established a solid reputation as a competent, well-trained physicist, with particular strength in statistical mechanics. He had also displayed in his papers a strong interest in the structure of matter and the ways molecules arranged themselves to form gases, liquids, and solids—problems at that time of more interest to chemists than to physicists.

When Herzfeld returned to Vienna late in 1918, he found the economic situation so bad that the university was in danger of closing. Conditions in Munich, only a four-hour train ride from Vienna, were somewhat better, and so Herzfeld decided to move there to study analytical chemistry, hoping eventually to land a job in the highly respected German chemical industry. But he found none of the challenge and thrill of discovery in the quantitative analysis laboratory that he had enjoyed in his more speculative and, for him, intellectually more exciting work in theoretical physics.

He therefore shifted back to physics and at the Ludwig-Maximilians-Universität in Munich attended the lectures of Arnold Sommerfeld, professor of theoretical physics, and of Kasimir Fajans, professor of physical chemistry. He impressed both professors so favorably that he was offered a position as *Privatdozent* in theoretical physics and physical chemistry, combined with an assistantship under Fajans for research in the latter field. Such an interdisciplinary appointment was a good predictor of the road Herzfeld's subsequent career would follow.

Physics in Munich was thriving because of Sommerfeld's ability and personality, and physicists well known to us today—such as Werner Heisenberg, Wolfgang Pauli, Otto Laporte, Fritz London, Gregor Wentzel, and Alfred Landé—all profited from spending time at Sommerfeld's institute. Herzfeld usually taught an advanced course in theoretical physics and one in physical chemistry. When Sommerfeld was away,

which happened quite frequently, Herzfeld took over his lectures. It appears that Herzfeld had a considerable impact on some of Sommerfeld's own research students, among whom were Walter Heitler[4] and Linus Pauling. Herzfeld's lectures were highly praised and well attended by chemists, for whom he kept the mathematics as simple as possible. At the same time he held special lectures on problems of greater difficulty for the physics and mathematics students.[5]

During his years in Munich (1919-26)—five years of which were spent as a *Privatdozent*—Herzfeld's research was dedicated to problems that straddled the fields of physics and chemistry. He made a major contribution to the theory of chemical reaction rates by showing that a third particle was always needed to supply the extra energy to produce a chemical reaction between two atoms or molecules (1919). The ensuing debate between defenders of Herzfeld's collision theory and the chemists' proposal that the extra energy required was provided by radiation from the walls of the reaction vessel was finally settled in Herzfeld's favor.

An important problem in physical chemistry was the relationship between statistical mechanics and thermodynamics. In an important paper in the *Zeitschrift für physikalische Chemie* (1920), Herzfeld investigated this relationship both from the standpoint of classical mechanics and of quantum theory. The next year (1921) Herzfeld published a long article in Felix Klein's *Encyklopädie der Mathematischen Wissenschaften* on Physikalische und Electrochemie, which indicated his main fields of interest at this early point in his career as a physical scientist.

Herzfeld's scientific productivity during his years in Munich was truly remarkable. He published the first modern book in any language on kinetic theory and statistical mechanics (1925), which soon became a very popular graduate-level textbook in German-speaking universities. In

the second edition of Hugh S. Taylor's *Treatise on Physical Chemistry*, Herzfeld and H. M. Smallwood wrote the sections on the kinetic theory of gases and liquids and on imperfect gases and the liquid state (1931). During his Munich years Herzfeld also contributed a number of important articles to the *Handbuch der Physik*, including one on Grösse und Bau der Moleküle (1924), another on Klassische Thermodynamik (1926), and a third with K. L. Wolf on Absorption und Dispersion (1928).

In addition to the above monograph on the kinetic theory of heat, his *Handbuch* articles, and two articles in the *Handbuch der Experimental Physik*, one of which was a long article on the lattice theory of solids (1928), Herzfeld published over 30 shorter research papers in German journals during the years 1919-26. One secret of his productivity was his ability to write most of his shorter papers without having to consult previously-read journal articles by other scientists on the same topic. He seems to have had an encyclopedic memory for the literature in both physics and chemistry, perhaps a result of the papers he wrote during World War I, when no scientific periodicals were available to him.

Herzfeld's research output has often been underestimated by physicists and chemists mainly for two reasons: (1) His published research was a rich mixture of articles on physics, articles on chemistry, and articles embracing aspects of both disciplines and (2) his interest in physics extended over a very wide range of topics, which made it difficult for him to become a leading authority in any one field. His name was well known and highly respected by all theoretical physicists in Germany in the 1920s, however, especially for his long, authoritative articles in the handbooks so popular with German physicists at that time.

Because he had been successful in both teaching and research, Herzfeld was finally named extraordinary professor

of theoretical physics in Munich for the academic year 1925-26. During that year he took over full responsibility for a number of courses previously taught by Sommerfeld. Then in 1926 Herzfeld left Germany quite unexpectedly. He had received an offer to become the first Speyer visiting professor at Johns Hopkins University in Baltimore. Because there were no attractive academic jobs available in Europe at the time, Herzfeld accepted this position with gratitude and enthusiasm.

Herzfeld's life in Baltimore was characteristically modest. For the ten years (1926-36) that he was on the faculty at Johns Hopkins, he lived in a dormitory room on Hopkins's attractive Charles Street campus. As a bachelor, he had no need for more space and he liked being close to his office and the university library. He learned English by going to the movies, especially to westerns, which he enjoyed immensely. In 1927 Princeton University offered Herzfeld a full professorship, but he turned it down, probably because he thought it unfair to leave Hopkins so soon after arriving there. The second physicist on Princeton's list, Eugene Wigner (Nobel Prize, 1963) took the position. This offer by Princeton strengthened Herzfeld's bargaining power with the Hopkins administration, and he succeeded in persuading President J. S. Ames to hire two additional young faculty members and to fund improved research laboratories for the physics department.

Herzfeld did considerable research at Johns Hopkins in collaboration with his colleague Francis O. Rice, a chemist born in Liverpool in 1890, who received his D.Sc. degree from Liverpool University in 1919 and spent the rest of his life in the United States. Rice joined the chemistry department at Hopkins as an associate professor in 1926, the same year Herzfeld arrived from Munich. Rice was interested in the same kind of physicochemical problems as Herzfeld,

and they soon began to work together. They published an important joint article in the *Physical Review*, under the title "Dispersion and Absorption of High-Frequency Sound Waves" (1928), which considered the role of molecular vibrations in the transfer of energy between ultrasonic waves and gas molecules. Herzfeld and Rice postulated that the velocity of sound propagating through a gas should depend not only on viscosity and heat conduction (as in classical theory) but also on the rate at which energy in the translational degrees of freedom of the molecules is exchanged with the internal degrees of freedom. They then sought to derive equations for the absorption and dispersion of sound waves in a gas that would lead to a characteristic relaxation time for this energy conversion process. This paper was extremely influential in proposing a novel way to use measurements of sound propagation to determine the rate at which molecules transfer energy from translational to vibrational modes of motion.

During his 10 years at Johns Hopkins, Herzfeld had the pleasure of seeing other European colleagues added to its physics faculty. These included two Nobel Prize winners in physics: James Franck (Nobel Prize, 1925) and Maria Goeppert-Mayer, who received her Nobel Prize only in 1963 after she and her husband, the physical chemist Joseph Mayer, had left Hopkins, first for the University of Chicago and in 1960 for the new campus of the University of California in San Diego. There Maria finally received her first regular appointment as professor of physics (at Hopkins she had only the title "research associate in physics"). When Maria Mayer was at Hopkins, Herzfeld published articles with her on the states of aggregation (1934), on the behavior of hydrogen dissolved in palladium and on the theory of nuclear fusion reactions (1935). He joined James Franck in publishing articles on a tentative theory of photosynthesis (1937),

on the photochemistry of polyatomic molecules, and (after they had both left Johns Hopkins) another article on a more complete theory of photosynthesis (1941).

The reasons for Herzfeld's move from Hopkins to Catholic University in Washington, D.C., at the end of the 1935-36 academic year are well set forth in a letter of May 19, 1936, from Herzfeld to Professor Arnold Sommerfeld in Munich.[6]

Herzfeld began this letter by discussing the unfortunate financial situation at Johns Hopkins. The university's deficit for the academic year 1935-36 was $270,000, and a drive for additional funds did not come close to raising this sum of money. The Hopkins physics department was very upset by the financial situation, and Herzfeld wrote that "I have the feeling of sitting on a volcano." Two other factors, moreover, aggravated the problem: first, his relations with R. W. Wood, professor of experimental physics at Hopkins from 1901 to 1938 and for many years its chairman, had deteriorated. Second, J. A. Bearden, another experimentalist on the Hopkins faculty, suspected that Herzfeld had ambitions to be chairman, and had brought Franck to Hopkins to foster that goal. Bearden also disliked what he considered the excessive emphasis on theoretical physics in the department, and the presence of so many German physicists in a rather small department. (In addition to Herzfeld, Franck, and Maria Mayer the Dutch spectroscopist G. H. Dieke was also a physics faculty member.) Bearden blamed Herzfeld for causing dissension in the physics department by his strong support of Maria Mayer for a regular faculty appointment.[7]

Herzfeld's unhappiness soon became common knowledge, and he received offers of professorships in the physics departments of both Fordham University in New York City and Catholic University. Neither of these was a strong research department, a situation that Herzfeld did not like, but he decided to talk over these two offers with Isaiah

Bowman, then president of Johns Hopkins. After listening to Herzfeld for a few minutes, the Hopkins president immediately suggested that Herzfeld would be wise to accept one of these firm offers, since there was no guarantee that Hopkins would not in the near future have to reduce the size of its physics faculty.

Herzfeld therefore decided to accept Catholic University's offer. The news of his leaving Johns Hopkins to go to Catholic University as professor and chairman of the physics department shocked many of the scientists at Hopkins, which had a reputation for a strong physics department from its very beginning in 1876, when Henry Rowland (1848-1901) had been its first chairman. Catholic University, on the other hand, had only five faculty members in its physics department, and none of them did much research. Herzfeld's teaching load and salary at Catholic University were to be about the same as at Johns Hopkins, but he would as chairman of the physics department have many more administrative duties to consume his time.

The members of the Johns Hopkins University chemistry department on March 12, 1936, felt so strongly about the departure of Herzfeld that they wrote a letter of protest to President Bowman containing the following sentiments:[8]

> We know of no theoretical physicist who enjoys nearly the reputation of Professor Herzfeld and who has at the same time the thorough knowledge of the science of chemistry and the acquaintance with chemical problems which he possesses. We regret particularly that the absence of Professor Herzfeld will necessarily mean the loss of a very efficient and fruitful connecting link between physics and chemistry.

Nothing ever came of this loyal protest by the chemists at Johns Hopkins. Two years later, however, F. O. Rice also left Hopkins and joined Herzfeld at Catholic University as chairman of its chemistry department.

Another, perhaps less important, factor in Herzfeld's decision to leave Johns Hopkins was related to his strong religious faith, which made him welcome the opportunity to become associated with a university that had a religious orientation. Herzfeld also saw in Catholic University's unique location in the nation's capital the opportunity to build a strong physics department by gradually adding a few outstanding part-time teachers, who in their full-time positions in government laboratories had already established impressive research reputations. This would allow him time to recruit a full-time research-oriented physics faculty. He also saw the need in Washington for substantial Ph.D. programs tailored to the needs of part-time students. These were often bright students with excellent M.S. degrees, who wanted to find an institution that would offer them the possibility of earning a solid doctoral degree. Herzfeld received encouragement for these ideas from the National Bureau of Standards administration and staff. These factors increased Herzfeld's confidence in the feasibility of what he planned to do. He probably would have been somewhat less confident had he realized the time and effort he would personally have to invest to convert his dream into a reality, but convert it he did.

In the late 1940s Herzfeld gave increased attention at Catholic University to quantum-mechanical calculations on the electronic structure of polyatomic molecules (1947, 1949), a field in which he and colleagues like C. C. J. Roothaan in the physics department and Virginia Griffing in the chemistry department trained many doctoral students (including this writer). Catholic University soon established a respected position in this field.

John C. Hubbard (1879-1954) had been one of the leaders in experimental ultrasonic research in the years 1927-46 at Johns Hopkins. After Hubbard's retirement from Hopkins

in 1947, Herzfeld invited him to Catholic University as research professor of physics. Beginning in the early 1950s Herzfeld devoted much time to theoretical work in ultrasonics to complement the experimental work of Hubbard and Theodore Litovitz, a gifted experimentalist on the Catholic University faculty. In 1959 Herzfeld and Litovitz collaborated on a book *Absorption and Dispersion of Ultrasonic Waves* (1959), a title almost exactly that of a theoretical contribution by Herzfeld 30 years earlier (1928). This book contains a summary of most of Herzfeld's thinking between the years 1928 and 1959 on many of the issues that most interested physical chemists at that time. Another very important theoretical paper, written about the same time, was the one by Schwartz, Slawsky, and Herzfeld (1952) on the calculation of vibrational relaxation times for gases.

The last 40 years of Herzfeld's life were warmed by his marriage in June 1938 to Regina Flannery of Washington, D.C., who was then an instructor in anthropology at Catholic University. By the time she retired in 1970, she had risen to be professor and head of that department. The Herzfelds had no children of their own, but a nephew, Charles Herzfeld, the son of Karl's only brother, August, was very close to them and, like his uncle, had a great interest in physical chemistry, in which field he obtained his Ph.D. from the University of Chicago in 1951. Charles Herzfeld became a well-known physical chemist and held many important leadership positions in government and private industry after World War II.

Karl Herzfeld retained ties with his family and with the German physics community by occasional visits to Germany. In 1948 he accepted an invitation from Arnold Sommerfeld to lecture on both theoretical physics and physical chemistry in Munich during the spring semester, and enjoyed this wonderful opportunity to spend some time with his old

colleague. In 1951 Sommerfeld was killed in an automobile accident while out walking with his grandchildren. Though this tragedy was enormously sad for Herzfeld, in 1958 he again accepted an invitation to lecture on physical chemistry during the spring semester in Munich.

Herzfeld was a wonderfully caring man: He cared about his students, his colleagues, his relatives, his friends, and even the maintenance workers in the physics building. He was also concerned about the future of physics, about philosophy and theology, about the role of religion and the problems of the world. On first meeting him in the summer of 1947, I was immediately struck by his stiff, almost military bearing. (He had, after all, reached the rank of first lieutenant in the Austro-Hungarian Army by the end of World War I.) However, I soon realized that beneath this protective cloak were a deep humanity, a surprising humility, and a penetrating understanding of people. (For example, he immediately saw through any attempt by a student to bluff his way through an oral examination or the answer to a question from a professor.)

He was a man of brilliant intellect who had an unusual breadth of knowledge in both physics and chemistry and a remarkable depth of interest in the most fundamental problems of physics. Still, he was willing to sacrifice his own success and future fame as a physicist to help a cause he thought more pressing: the improvement of physics instruction and research in his adopted country.

Although Herzfeld pushed his colleagues and students to produce, he drove himself to work harder than anyone else in the physics department (as a graduate student I was tempted at times to think that he might have been even more productive as a scholar if he had not been overly tired from teaching evening graduate courses to accommodate part-time students). His work ethic was astonishing.

His door was always open to both faculty colleagues and to students. (There were even recurrent rumors around the Catholic University campus that he had assisted physics students with his own money when they were in dire financial need.)

Of the 85 Ph.D. degrees awarded by Catholic University in the years 1936 to 1962, when Herzfeld chaired the department, almost half were directed by Herzfeld himself. Every Saturday he set aside the whole day for meetings with a number of theoretical students who were working on Ph.D. dissertations under his direction. (In one case he even agreed to be available in his office at the university on Sunday to meet with an orthodox Jewish student who could not come on Saturday.) Herzfeld was also generous with his ideas, many of which appear in the published literature under the names of the students he mentored.

He was extremely scrupulous in using university funds. On one occasion he was found wandering through the physics building looking for a pay phone to call the automotive shop where his car was being repaired, since he thought it improper to use his own office phone for anything but business calls. He found time, however, for an occasional joke. One he especially enjoyed ran as follows: “There was a teacher who was dreaming that he was teaching a class and when he woke up, he found that he was!”

In encouraging women and blacks to pursue careers in physics Herzfeld was far ahead of his time. At Johns Hopkins he published research papers jointly with Maria Mayer and invited her to join him in conducting a seminar on the quantum mechanics of molecules. He published three papers with Virginia Griffing of the Catholic University chemistry department (1955) and another with Hertha Sponer, James Franck’s wife. Then, after World War II he brought Lise Meitner to Catholic University as a visiting professor for the

spring 1954 semester. Finally, of the 85 Ph.D. degrees awarded in the years 1936-62, about 10 percent went to women, which was an unusually high percentage for those years.

Herzfeld also entered into an informal arrangement with Howard University in which the physics chairman there agreed to steer his best and brightest black students in physics to Catholic University for their advanced degrees, because they had Herzfeld's assurance that he would do everything in his power to make the Howard students feel at home on the campus and provide any assistance needed on their road to a Ph.D. This arrangement worked well at first, but later fell victim to the increased efforts of the biggest and best physics departments in the country to recruit graduate students from black colleges with offers that Catholic University could not match.

After enjoying excellent health throughout most of his life, just a year before his death Herzfeld began to fail. He suffered a severe stroke at his home in Washington in late May 1978, and an ambulance took him to George Washington University Hospital, where he died peacefully a few days later on June 3.

Those of us who profited so greatly from the teaching and advice of this kindly, dedicated, and uniquely skilled mentor will always be grateful for the opportunity Karl Herzfeld gave us to share in the great European tradition of theoretical physics that he represented and that he communicated so generously to his students and colleagues.

Herzfeld was elected to the American Academy of Arts and Sciences in 1958 and to the National Academy of Sciences in 1960. He was a fellow of the American Physical Society and of the Acoustical Society of America. During World War II he served on a number of Navy advisory committees and in 1964 he received the Navy's Meritorious Service Citation for his research and service as an advisor to the

Navy during the war. Some words of Elliott Montroll in 1984 are worth repeating here:[9]

> At Catholic University, he [Herzfeld] developed a program to respond to the needs of young staff members of the many government laboratories, especially the National Bureau of Standards and the Navy laboratories. Many part-time students from these organizations received their Ph.D.'s under his sympathetic direction. . . . The Catholic University acoustics program initiated by Herzfeld had a profound influence on the Navy underwater sound program. . . .

Herzfeld received many honorary degrees and other tributes. Among these were honorary doctorate of science degrees from Marquette University, Milwaukee (1933); University of Maryland, College Park (1956); Fordham University, New York (1960); Technische Hochschule, Stuttgart (1962); Providence College, Rhode Island (1965); and an LL.D degree from the University of Notre Dame, Indiana (1965). He received the Mendel Medal from Villanova University in 1931, the Secchi Medal from Georgetown University in 1938, and the Cardinal Gibbons Medal from Catholic University in 1960. In 1964 he received the Bene Merenti medal from the Vatican for his 28 years of distinguished service to the Catholic University of America.

THE CONTENTS OF THIS BIOGRAPHICAL memoir are based in great part on materials provided by the National Academy of Sciences and on the Archival Collections at the American Institute of Physics Niels Bohr Library in College Park, Maryland. The most relevant Herzfeld documents in the American Institute of Physics collection are designated as OH 213 and OH 214 (oral history interviews), AR 85 (archives) and MB 246 (a manuscript biography of Herzfeld).

I have also profited from two long interviews with Regina Herzfeld, whose insights into her husband's career and contributions to science have made this memoir both more accurate and more interesting; from meetings, telephone conversations, and correspondence with faculty members who had been contemporaries of Karl Herzfeld on the Catholic University of America physics faculty—including, in

particular, James Brennan, Theodore Litovitz, and Paul Meijer. In addition, other colleagues of mine—including Fernand Bedard, Russell McCormmach, Donald Osterbrock, and Alfons Weber—have read this paper at various stages of its development and have by their perceptive comments greatly improved its final form. I am especially grateful to Charles Herzfeld, Karl's nephew, for suggesting some significant changes that improved the final form of this memoir.

The article by Karen E. Johnson referred to in Note 8 was of great assistance in my understanding of Herzfeld's early contributions to science and especially to statistical mechanics. I found the 1936 letter of Herzfeld to Sommerfeld referred to in Note 6 at the Deutsches Museum in Munich when I was in Germany in 1988. I am grateful to the Deutsches Museum for making a copy of this important document available to me.

Finally, I would like to express my thanks to Heather Lindsay of the Niels Bohr Library and to Jenny S. Mun, biographical memoirs coordinator of the National Academy of Sciences, who generously provided me with the helpful assistance I needed to complete this project.

NOTES

1. J. A. Wheeler. Karl Herzfeld. *Phys. Today* (Jan. 1979):99. This is a short but beautiful and moving obituary of Karl Herzfeld by his best-known and now most renowned doctoral student. In this one-page obituary Wheeler writes, "Physics for Herzfeld was not a secular, but a religious calling; it aimed, in his view, to make clear the structure and beauty of God's creation."

2. Quote from a brief typewritten (nine double-spaced pages), unpublished autobiography by K. F. Herzfeld, p. 4. This short autobiography was probably prepared by Herzfeld for the American Institute of Physics in 1963, at which time he also sent a copy to the National Academy of Sciences. This copy still remains in the Academy's archives.

3. Oral History OH 213, p. 11.

4. Heitler chose Herzfeld as his mentor for his Ph.D. dissertation because his research was "sort of border line between physics and chemistry." Interview of Heitler by John Heilbron on March 18, 1963. OH 205, p. 5.

5. In OH 204, p. 7, Werner Heisenberg makes the terse statement: "Herzfeld was a good teacher, so I liked his lectures."

6. Letter of May 19, 1936, from Herzfeld to Arnold Sommerfeld in Munich, Germany. This letter is in the Sommerfeld Archive at the Deutsches Museum in Munich.

7. In OH 214, p. 21, Herzfeld confesses that he turned down R. W. Wood's position as chairman of physics and then acted as if he really were the chairman. He also admits that, in retrospect, he probably did try too hard to bring European physicists to the Johns Hopkins University physics department, despite the fact that a number of his colleagues there were not enthusiastic about his initiative in this regard.

8. Members of the Johns Hopkins chemistry department to President Isaiah Bowman, March 12, 1936; in Joseph Mayer Papers, University of California, San Diego; in Special Collections Department, University Library, UCSD. This useful document is referred to by K. E. Johnson in "Bringing Statistical Mechanics into Chemistry: The Early Scientific Work of Karl F. Herzfeld," *J. Stat. Phys.* 59 (1990):1547-72, on p. 1549.

9. E. W. Montroll. On the Vienna school of statistical thought. *Am. Inst. Phys. Conf. Proc.* 109(1984):1-10, on p. 7.

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Karl Herzfeld published some 140 articles, 2 books, and 13 lengthy articles in a variety of handbooks on physics and physical chemistry. Only about 15 percent of the most important of these are listed below in order of date of publication. The first reference to any particular journal gives the full name of the journal; any subsequent references are abbreviated. For example, *Annalen der Physik* is abbreviated to *Ann.Phys.*

1912

Über ein Atommodell, das die Balmer'sche Wasserstoffserie aussendet. *Sitzungsberichte der Koniglichen Akademie der Wissenschaften Wien* 121(2a):593-601.

1913

Zur Elektronentheorie der Metalle. *Annalen der Physik* (4) 41:27-52 [Herzfeld's doctoral dissertation at Vienna University under the direction of Professor Friedrich Hasenöhrl).

1919

Zur Theorie der Reaktionsgeschwindigkeiten in Gasen. *Ann. Phys.* 59(4):635-67.

1920

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1921

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1924

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1925

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