NATIONAL ACADEMY OF SCIENCES

GERTRUDE SCHARFF GOLDHABER
1911–1998

A Biographical Memoir by

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Biographical Memoirs, VOLUME 77

PUBLISHED 1999 BY
THE NATIONAL ACADEMY PRESS
WASHINGTON, D.C.

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July 14, 1911–February 2, 1998

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THROUGHOUT HER LIFE Gertrude Scharff Goldhaber had to struggle against tyranny and discrimination, as a child during World War I, as a Jew in Nazi Germany, as a woman in a scientific discipline when there were few such practitioners, and as the wife of another scientist at a time of strict nepotism rules. That she was so successful is a testament to her talent, drive, and will.

A person's life has peaks and valleys, sometimes so gentle that even the one living that life is barely aware of them, and sometimes so sharp that a mere glance is enough to bring them into high relief. Neither type is better or worse, but the dramatic form gives clearer insight into character, the most important thing one can learn about any person. Trude's life definitely belongs in the dramatic category.

We knew Trude, as she was called by her friends, above all as a dedicated physicist. She was often passing on news about a recent advance, whether hers or others. Despite all the hardships she endured, she was predictably cheerful. Probably, her happy marriage and family life helped her achieve an ever-cheerful disposition.

Gertrude Scharff was born in Mannheim, Germany, on July 14 (Bastille Day), 1911, just a short time before the relative serenity of the previous century was shattered by the outbreak of World War I. Many people know about the battlefield horrors of that war, but even well behind the lines things were tough. Trude recalled bread made partly of sawdust—good roughage but not very nutritious!

She attended public school in Mannheim, where she developed an interest in science, with the support of her parents (surprising for that time), perhaps because her father had to abandon a plan to go into chemistry at the age of sixteen when his father died and it became necessary to work in the family's food wholesaling business. Even with the end of the war, life in Germany was difficult, with hyperinflation in the mid-1920s, followed by worldwide depression. Nevertheless, Trude went on with her studies, entering the University of Munich and fairly soon coming to focus on physics. Although her father preferred that she be a lawyer, she recalled saying, "I'm not interested in the law. I want to understand what the world is made of."[1]

A frequent pattern in those days was for students to spend semesters at various universities, and she did that three times, visiting Freiburg, Zurich, and Berlin before settling down to thesis research with Walther Gerlach at Munich. In Berlin she first met her future husband. We are unaware of any local female mentors or role models, but she had good relations with her professors.

A major problem arose with the accession of the Nazis to power in 1933. It became increasingly difficult for Jews working at a university or running a business to continue to do so, and next to impossible for one to find a position. Her father was jailed, and after release went with her mother for a short stay in Switzerland. After returning, they never succeeded in leaving Germany again; both perished in the Holocaust.

Meanwhile, Trude attained her Ph.D. in 1935; as work in

Germany was impossible, she headed for London. Her younger sister Liselotte had already left Germany and currently resides in France. Trude stated "I should have left earlier, but since I had started my thesis I felt I should finish."[2] Having a Ph.D. degree actually was a disadvantage, as there was more room for refugee students than refugee professionals. For six months Trude lived from the proceeds of selling a Leica camera and translating German manuscripts into English. Eventually she got a job in a lab run by G. P. Thomson, but she never obtained a real position. In 1939, prior to the beginning of World War II, she and Maurice Goldhaber married, and she moved to join him at the University of Illinois in Urbana.

An issue of women in science then came to the fore. Maurice already was on the faculty at Illinois, and so, according to strict interpretations of state anti-nepotism laws, she could not be hired as well. Beyond that she was not even allowed lab space, so her only options were to quit research or to accept her husband's invitation to join him in his lab, with no salary, of course. With her drive, there was no real choice. Not only was she unpaid, which meant that Maurice's salary had to cover all costs, including in due course child care for their two sons Alfred and Michael, but also she had to switch fields to make use of the resources in the lab, which was devoted to nuclear physics. Obviously, she made the transition with considerable flair.

Finally, some time after the war, she was placed on a soft-money line in the Physics Department at Illinois. We have heard that women faculty there in more recent times have expressed a debt to her for waging a struggle that at least weakened the resistance to hiring women that she experienced and made life easier for her successors. In 1950 the family moved from Illinois to Long Island, where Maurice and Trude both joined the scientific staff of Brookhaven

National Laboratory. It was fifteen years after obtaining her doctorate that Trude for the first time received a regular long-term, paid position. During almost all of the intervening time she had been engaged in experimental physics research, but without the recognition that would normally have been expected for her accomplishments. The only time she was not doing research was during part of the war, when she joined an engineer at Illinois in applied work.

Trude was always willing to help the profession by serving on committees. She was elected a fellow of the American Physical Society in 1947, and in 1972 became only the third female physicist to be elected to the National Academy of Sciences. She was a member of the Advisory Board for the Nuclear Data Tables and Sheets and served as chair of the National Research Council Panel on Nuclear Data Compilations. She was a member of the American Physical Society's (APS) Committee on the Status of Women in Physics and served on the National Science Foundation's Advisory Committee for the Physical Sciences and as a member of the Board of Trustees of Universities Research Association, Inc. She was an APS councilor and chair of its Panel on Pre-College Physics Education. She also served on many other committees. She received the Long Island Achiever's Award in Science in 1982 and the 1990 Outstanding Woman Scientist Award from the New York Chapter of the Association for Women Scientists. She initiated a training institute for Suffolk and Nassau County science and mathematics teachers and in 1960 she started the still justly famous monthly Brookhaven Lecture series. Trude served as a Phi Beta Kappa visiting scholar in 1984-85.

Now to her research. In Munich for her doctorate Trude studied the effects of stress on magnetization (1936) and completed her degree in 1935. She recalled her job hunt: "I wrote to 35 refugee scientists. They all wrote back and said, 'Don't come here. There are already too many refugees.' "[2] Actually one did write back with hope—Maurice Goldhaber, who was in Cambridge, thought something might turn up. Trude joined G. P. Thomson as a postdoc where she worked on electron diffraction. Once she got into nuclear physics she continued to focus on what today would be called low-energy aspects of the subject. Working with students who later had distinguished careers, she studied neutron-proton and neutron-nucleus reaction cross sections (1941) and then gamma radiation emitted or absorbed by nuclei (1942). In the early 1940s, Trude found that spontaneous nuclear fission, which might have been a gentler process than neutron-induced fission, is also accompanied by the emission of one or more neutrons. While such neutron emission was widely suspected to occur, she appears to have been the first to make a direct observation of this important phenomenon. The work was classified during the war, so it was not published until after the war was over (1946).

Shortly after the war, she and Maurice collaborated on an important experiment about the nature of elementary particles. The electron was the first explicitly identified elementary particle, and had been accepted as a basic constituent of atoms and therefore of all familiar matter. In certain rare processes, known as weak decays, so-called beta particles were produced that looked very much like electrons, and it was worth knowing whether they were identical to electrons. Many experiments had tried to find a difference by precisely measuring the charge-to-mass ratio for electrons and beta rays. What Trude and Maurice did in their experiment (1948) was to let beta particles impinge on lead, whose atoms have a large atomic number. If the betas were different from electrons, they could occupy the same locations as deeply bound atomic electrons, and therefore could fall in towards the nucleus of an atom, releasing a large amount of energy in the process. If they were identical, the Pauli exclusion principle would prevent the betas from doing so. The lack of X rays carrying the required energy showed that the beta particles must be indistinguishable from electrons. She also carried out important investigations of very long-lived excited states of nuclei, so-called isomers or isomeric states (1948, 1950, 1951).

A little later, Trude started to focus on her life work, determining the properties of nuclei when they are only "tickled" or excited a bit, a field where little was known when she started. In many cases, an excitation may be pictured as a slow rotational or vibrational motion of the nuclear medium as a whole, rather than just one nucleon jumping into an excited state like an electron in an atom (1952, 1953, 1954). Her early studies of such systems were an important component of the background for the collective theory of nuclear motion, which earned a Nobel Prize for Aage Bohr and Ben Mottelson.

From the early 1950s onward, Trude directed her scientific research to systematizing the properties of nuclear levels across the entire periodic table. Being methodical and purposeful she was ideally suited for these studies. It was a time of rapid development in both experimental techniques and nuclear structure theory. Both independent-particle and collective-motion models were proposed to describe nuclear excitations, but the delineation of the regions of applicability of each was not well defined. The then-recent Mayer-Jensen shell model appeared to contradict what was known about the short-range saturated nuclear forces, with their implied pronounced nucleon clustering: there was speculation that the forces that were known to act between free nucleons were somehow modified in dense nuclear matter and that shell structure existed only for ground states. Evidence for shell closures in heavier nuclei lacked experimental evidence. Trude's research at this time was devoted to resolving these apparent contradictions. In 1953, Trude demonstrated the influence of shell structure on excited nuclear states through a detailed and comprehensive survey of the energy of the first excited states of even-even nuclei as a function of neutron number. Her conclusions included the important contribution that the excitation energy increased strongly at the shell closures.

A few years later she noted that the ratio of excitation energy of the second excited state to the first in nuclei in the $38<N<88$ region was much different than that in the adjacent region of $90<N<108$. The value in the lower mass region is near the ratio of 2 identified with phonon excitation in spherical nuclei, whereas in the upper mass region the value is near 10/3, signaling an abrupt change to the rotational states of deformed nuclei (1955). In 1957, she reported the remarkable isomerism in Hf-180 with its implied retardations of 10^{-16} and 10^{-9} for the E1 and E3 transitions respectively, dramatically verifying the prediction that in deformed nuclei there is a strong inhibition of electromagnetic transitions where the projection of spin along the symmetry axis changes.

Over many of the following years she developed the phenomenological variable moment of inertia (VMI) model (1969, 1970, 1976) and was able to smoothly parameterize the energy ratio of the first 4+ to 2+ states of the even-even nuclei over most of the periodic table with values ranging from about 2.2 to 10/3. In addition, this model gives a semi-empirical description for intrinsic and transition quadrupole moments and level energies. This also led to what may have been the first mother-son collaboration in physics. Famous precedents existed for all the other parent-child combinations, but not for this one. The joint work (1970, 1978) was based on the idea that if the nucleus has a distorted shape, that fact should be seen both in its rotational behavior and in the electromagnetic radiation due to a related distortion in the distribution of electric charge. In these publications a case was made that there is a simple and instructive relation between the electrical and the mechanical deformation of the nucleus. Her research culminated with studies of high spin states, states that tend to be at the limit of high deformations (1973, 1983).

A tool that Trude developed to explain her findings to others, three-dimensional plots, has evolved into something so commonplace in this computer age that its origins may have been forgotten. In her case, the energy of the lowest nuclear excitation was plotted against the number of protons and the number of neutrons in the nucleus. To accomplish this, wooden bars with height proportional to the escalation energy were glued onto the appropriate isotope on the chart of the nuclides. In this way, one could see peaks and valleys, which gave an immediate intuition about the changes in behavior from one set of nuclides to another. Nowadays this kind of visualization is done with computer graphics and so has become much easier, if not as tangible.

Taken as a whole, Trude Goldhaber's work played an integral part in unfolding the story of nuclear structure, alerting experimentalists to regions of the periodic table of importance and confronting theorists with the realities of nature.

Throughout her life Trude faced adversity, and worked hard to overcome it. She was tenacious in her arguments and had a forceful personality. After starting in a regular position so late she was compelled to retire (in a way that couldn't happen now) at the age of sixty-six, as was the policy at Brookhaven National Laboratory. Her regular employment lasted only 27 years. For someone looking only to earn a living this might have been acceptable or even welcome, but for a dedicated researcher like her it was another blow. She continued for some years as a collaborator with researchers holding grants at other institutions, but the eventual end of that support left her angry. It would have been easy for the all-too-understandable anger to become bitterness, but that never developed.

Both long ago and since her death many people, men as well as women, have noted how she reached out to help and encourage them as they were starting out or at any stage when they were facing difficulties, whether professional or personal. Besides this kind of individual concern, she worked both at Brookhaven and on the national scene to develop educational initiatives and opportunities for schoolchildren, university students, community members, and, of course, people already working in research. Her part in founding Brookhaven Women in Science is a characteristic example. Her interests were not confined to nuclear physics. She closely followed developments in biology and medicine, and many senior figures in those fields enjoyed and appreciated her involvement. Outside science she was interested in how mythology reflects a civilization, and she was an avid tennis player and mountain climber.

Even when her disabilities began to constrain her more and more, she continued each day as she had all her life to find fulfillment in what she still could do and experience. This readiness always to appreciate the positive and to maintain her dignity in the face of limitations and adversity was as admirable as it was amazing. With her intermittent hospitalizations, the last years were akin to a stone skipping on the water, rising again and again, usually not quite as high as the previous time, and finally disappearing into the waves.

Her contributions to science, to education, and to gaining recognition and equality for women will have a lasting impact.

IN PREPARING THIS manuscript we received important help and contributions from Alfred Goldhaber and Chellis Chasman.

NOTES

1. Obituary. *New York Times*, Feb. 6, 1998, p. D18.

2. E. Pennisi. Distinguished physicists manifest lifelong commitment to succeed. *Sci.* 4(1990):7.

SELECTED BIBLIOGRAPHY

1936

The effect of stress on the magnetization above the Curie point. *Ann. Phys.* 25:223.

1941

With W. E. Good. Total cross sections for 900-keV neutrons. *Phys. Rev.* 59:917.

1942

With G. S. Klaiber. Photoneutrons produced in beryllium by the gamma rays of radio antimony (60d). *Phys. Rev.* 61:733.

1946

With G. S. Klaiber. Spontaneous emission of neutrons from uranium. *Phys. Rev.* 70:229.

1948

With M. Goldhaber. Identification of beta rays with atomic electrons. *Phys. Rev.* 73:1472.

With G. Friedlander and M. Goldhaber. Long-lived metastable state of Te^{125}. *Phys. Rev.* 74:981.

1950

With A. W. Sunyar, D. E. Alburger, G. Friedlander, and M. Goldhaber. Isomerism in Pb^{204}. *Phys. Rev.* 78:326A.

1951

With M. Goldhaber, E. der Mateosian, A. W. Sunyar, M. Deutsch, and N. S. Wall. Isomeric state of Y^{89} and the decay of Zr^{89}. *Phys. Rev.* 83:661.

1952

Excited states of even-even nuclei. *Physica* 18:1105.

1953

Excited states of even-even nuclei. *Phys. Rev.* 90:587.

1955

With J. Weneser. Systems of even-even nuclei. *Phys. Rev.* 98:212.

1957

Recent advances in the systematics of even-even nuclei. Proceedings of the University of Pittsburgh Conference, June 6–8.

1959

With M. McKeown. Triple isomerism in Ir^{192}. *Phys. Rev. Lett.* 4:25.

1969

With M. Mariscotti and Brian Buck. Phenomenological analysis of ground state bands in even-even nuclei. *Phys Rev.* 178:1864.

1970

With A. S. Goldhaber. Extension of the variable moment of inertia model toward magic nuclei. *Phys. Rev. Lett.* 24:1439.

1973

With M. McKeown, A. H. Lumpkin, and W. F. Piel, Jr. Forking of ground state bands in ^{102}Pd and ^{100}Pd. *Phys. Lett.* 44B:416.

1976

With C. Dover and A. Goodman. The variable moment of inertia (VMI) model and theories of nuclear collective motion. *Annu. Rev. Nucl. Sci.* 26:239.

1978

With A. Goldhaber. Electric and dynamic quadrupole moments of even-even nuclei. *Phys. Rev.* C17:1171-78.

1979

Pseudomagic nuclei. *J. Phys. G (London)* 5: L207-11 (corr. 6:413).

1983

With W. F. Piel, Jr., C. J. Lister, and B. M. Varley. High spin states of ^{94}Ru and ^{96}Pd. *Phys. Rev.* C28:209.