BIOGRAPHICAL MEMOIRS

HERBERT FRIEDMAN

21 JUNE 1916 · 9 SEPTEMBER 2000

HERBERT FRIEDMAN died of cancer at his home in Arlington, Virginia, on 9 September 2000, at the age of eighty-four. He was a pioneer in the application of sounding rockets to solar physics, aeronomy, and astronomy. He was also a statesman and public advocate for science. During his lifetime, he was awarded the Eddington Medal of the Royal Astronomical Society, the National Medal of Science, the Henry Norris Russell Award of the American Astronomical Society, the William Bowie Medal of the American Geophysical Society, and the Wolf Foundation Prize in Physics, among others. He was elected a member of the National Academy of Sciences in 1960 and of the American Philosophical Society in 1964. His service to science included membership on the General Advisory Committee to the Atomic Energy Commission during Lyndon Johnson's presidency, on President Nixon's Science Advisory Committee, and on the Space Science and Governing boards of the National Academy of Sciences.

Friedman spent his professional career at the Naval Research Laboratory, arriving in 1940 after completing his graduate work at Johns Hopkins University. He retired in 1980 but maintained an active association with the laboratory and its community until his death. One of his last activities was organizing a symposium for the American Philosophical Society in April 2000 called "Ballistic Missile Defense, Space, and the Danger of Nuclear War," which included talks by Richard Garwin, Gregory Canavan, Roald Sagdeev, and others.

Friedman was born in Brooklyn, the second of three children of Samuel and Rebecca Friedman. His father was an Orthodox Jew who moved to New York City from Evansville, Indiana, and eventually established a successful art framing shop on East Ninth Street in Manhattan. Friedman's mother was born in eastern Europe. Friedman grew up as an aspiring artist and earned pocket money as a young man from the sale of his sketches.

He entered Brooklyn College in 1932 as an art major, but ended up with a degree in physics. He was influenced by his first physics professor, Dr. Bernhard Kurrelmeyer, who eventually helped him get a scholarship to Johns Hopkins. Also, Friedman told me he had been swayed by a bad experience with a sculpture instructor. The same block of clay was reused from one semester to the next, and the new students had to work the clay to soften it. Friedman's approach was to jump up and down on it, which appalled his instructor. "You have no feeling for the medium," he was told. Friedman was playing out the punch line of an old story about the difference between biologists, chemists, and physicists. Coming across a strange object washed up on a beach and using the tools of their trades to determine its nature, the biologist draws a picture of it, the chemist tries to dissolve it, and the physicist kicks it.

By the time Friedman began his graduate studies in 1936, physics (especially in relationship to the nature of the atom) had been totally transformed since the beginning of the century. Quantum mechanics, combined with powerful new diagnostic tools such as X-ray technology and X-ray diffraction, led to an entire industry dedicated to understanding the structure of matter, picking up where the chemists had left off. For his thesis research at Johns Hopkins, Friedman studied X-ray interactions with various materials, mostly metals.

Friedman sought an industrial position when he finished at Hopkins in 1939. There were none to be had, so he remained at the university for a year as an instructor. In 1940, he joined the Metallurgy Department at NRL. The titles of his papers during the 1940s reveal the applied nature of his work: "Thickness Measurements of Thin Coatings by X-ray Absorption" and "Determination of Tetraethyl lead in Gasoline by X-ray Absorption." During this time, he also applied for his first of what would eventually be fifty patents. In spite of his personal productivity in the Metallurgy Department, Friedman chafed at a leadership that restricted work to applications involving very traditional technology. In 1942, he was prepared to leave and take a position at the National Bureau of Standards. By then, however, Friedman had become known to E. O. Hulburt, who directed NRL's Optics Division. Hulburt, a widely respected scientist and a Hopkins graduate, offered Friedman a position as the head of a newly formed section dedicated to exploiting electron microscopy and X-ray diffraction analysis. Friedman was only twenty-six years old.

In 1945, Friedman received the Navy's Distinguished Civilian Service Award for the wartime development of a technique for cutting RF crystals for radios by using their Bragg reflection characteristics. Until Friedman's innovation, crystals were examined visually in order to find the correct orientation for installation into radio circuits. But the Japanese had bought all the good crystals on the world market while building up their armed forces. All that remained was low quality crystals, not suitable for visual examination. So Friedman took what was available and demonstrated how they could be "visualized" with X-rays and converted to use in radios. The award citation states that fifty million man-hours of effort were saved with Friedman's development.

Friedman also became involved in the search for airborne radioactive dust as an indicator of nuclear explosions. The standard technique for the analysis of airborne dust was then (and still is now) collection on filter paper placed in an air stream. Aircraft had to be used to carry the sampling apparatus. Friedman recognized that rainfall had the property of scouring the air of such particles, which acted as nucleation centers for creating raindrops. Why bother going up into the stratosphere to collect material when nature will bring it down in the form of rain, reasoned Friedman. Combined with techniques developed by NRL chemists for extracting and condensing heavy elements from rainwater, this elegantly simple idea turned into a powerful means of detecting small amounts of atmospheric inclusions. The NRL effort, dubbed Project Rain Barrel, resulted in the detection in 1949 of the Soviet Union's first nuclear explosion, and produced such detailed information that for years Stalin was convinced the U.S. had a master spy operating in his bomb program.

This record alone established Friedman as an unusually gifted scientist. Yet by 1949 he was already shifting his primary interest to launching scientific experiments from sounding rockets in order to study the sun and the upper atmosphere. In 1946, the year that the first V-2 rockets were launched in the United States with science payloads, Friedman was working in E. O. Hulburt's division at NRL. Members of Hulburt's division were among the first U.S. scientists to exploit this new capability, in particular to study the sun and upper atmosphere. Friedman's first rocket experiment, launched from the White Sands missile range in 1949, observed solar X-ray and ultraviolet radiation using Geiger counters. The abstract to his 1951 paper published in the *Physical Review* described the results this way: "Data telemetered continuously from photon counters in a V-2 rocket, which rose to 150 km at 10:00 A.M. on September 29, 1949, showed solar 8A X-rays above 87 km, and ultraviolet light around 1200A and 1500A above 70 km and 95 km, respectively. The results indicated that solar soft X-rays are important in E layer ionization, that Lyman α-radiation of hydrogen penetrates well below E layer, and that molecular oxygen is rapidly changed to atomic above 100 km." Friedman's experiment confirmed the existence of solar X-rays and provided a clean and quantitative glimpse of how the structure of the upper atmosphere was created.

The switch from laboratory X-ray analysis to rocket atmospheric science was not as abrupt as it seems. The key to Friedman's rocket instrument was the small, rugged gas detector, along with the associated electronics that he developed for his laboratory work. The basic science of his rocket investigations (the production of X-rays and their interaction with matter) consisted of subjects he had been studying since graduate school days. What is remarkable is that Friedman abandoned a very successful research career in material sciences to pursue a new area of research involving the extremely high risk of flying rockets.

During the next decade, Friedman arranged for campaigns of shipboard rocket launches, including one near Puka Puka Island during the 1958 solar eclipse, obtained the first X-ray image of the sun with a pinhole camera, flew the first Bragg spectrometer for measuring hard

X-rays, and developed and flew the first satellite, SOLRAD, for long-term monitoring of the sun.

Friedman moved on to more general astronomical observations in 1955 with a rocket flight using Geiger counters sensitive to ultraviolet radiation. This experiment revealed significant emission associated with the Milky Way. Following the discovery of cosmic X-ray sources in 1962, Friedman conducted a rocket flight in early 1963 that unambiguously confirmed the presence of discrete sources of X-rays and of a diffuse X-ray background. In 1964, he conducted one of the most noteworthy experiments using sounding rockets to observe the Crab Nebula as it was occulted by the moon. Friedman's group continued rocket observations of X-ray sources for another decade, and under his leadership, they developed and built one of the instruments on NASA's first High Energy Astronomical Observatory, launched in 1977.

While Friedman's scientific research flourished during the sixties, his career took on an added dimension when he was elected to the National Academy of Sciences, at the beginning of that decade. On paper, this is simply one of Friedman's many honors, but it coincides with the beginning of a period of intense devotion to service in national and international scientific organizations and to issues of space policy. The first of these activities was his membership on the Geophysical Monograph Board of the American Geophysical Union in 1959. By 1962, he was involved in ten other such activities. In part, this was the result of the creation of NASA, which had an advisory structure relating to the space sciences. Friedman, as a recognized leader in his discipline, was naturally asked to join. Furthermore, given Friedman's contributions to applied research with its relationship to national defense programs, he was a natural choice for other groups. By 1970, the number of his concurrent activities reached seventeen, whereas other active scientists rarely have the energy and ability to participate in more than a few simultaneously.

About the same time, Friedman embarked on a project not related to his personal research. In 1962, he proposed successfully to the National Science Foundation that an institute be created at NRL—the E. O. Hulburt Center for Space Research—dedicated principally to the mentoring of young scientists in space research. Friedman argued that "there can be little doubt that major advances in astrophysics can be achieved in the immediate future through the use of observatories in space, yet in spite of substantial funding by NASA for space science in the universities the opportunities to enter directly into rocket and satellite astronomy programs are very limited." He noted that the principal focus of NASA, which was satellite projects such as the Orbiting Solar Observatory and the Orbiting Astronomical Observatory, "are inappropriate for graduate students and in any case are too inflexible as testing grounds for unconventional and radically new ideas." He argued that because of its history of excellence in space science and the breadth of laboratory support services, the Naval Research Laboratory was uniquely situated for training scientists to participate in space research and technology. The Center went on to train many postgraduates who became leaders in the space sciences.

Friedman's influence in the scientific community can also be gauged from his role in the formation of the International Geosphere/Biosphere Program, a term that he coined. A NASA-sponsored workshop was held in the summer of 1982 to discuss a major new space initiative in the area of "global habitability." Given the interest expressed by various groups, Friedman organized a workshop the following summer under the auspices of the National Academy to "begin a more systematic, detailed discussion of the composition of the International Geosphere/ Biosphere Program." The workshop resulted in a report presented to the International Council of Scientific Unions in August 1983. This in turn led the Council to issue "A Proposal for an International Geosphere/ Biosphere Program—a Study of Global Change," which was endorsed at the IGU General Assembly in 1984. A parallel effort was begun in the United States by the National Research Council with the formation of the Committee for an International Geosphere/Biosphere Program. The net result has been an astonishing number of programs and even an act of Congress, "The Global Change Research Act of 1990."

Friedman's emergence as a space scientist was anything but inevitable. His first choice when he left graduate school was an industrial position, in which he could apply the experience of his thesis work. But 1939–40 was still the Depression and he was competing, as a physicist, for a position in a discipline dominated by chemists. Furthermore, he was Jewish and anti-Semitism was still alive in corporate America. After a short time at NRL, only friendship with E. O. Hulburt kept him from taking a position at the National Bureau of Standards. Finally, it was only because the Naval Research Laboratory seized the opportunity to do research with captured V-2 rockets that space research arose at all. The trajectory of Friedman's career always led to basic science. On three occasions, he abandoned promising careers to pursue more fundamental science. He started out by switching from art to physics as an undergraduate and ended up doing research on the properties of neutron stars and black holes, which are among the more esoteric objects in the universe.

Friedman authored or co-authored more than three hundred scientific publications and wrote three books for the general public. Those books are filled with memorable sayings and quotations. The one below is especially appropriate as the scientific community tries to make itself accountable for society's goals:

> SOCRATES: Shall we make astronomy our next study? What do you think?
>
> GLAUCON: Certainly, a working knowledge of the seasons, months, and years is beneficial to everyone, to commanders as well as to farmers and sailors.
>
> SOCRATES: You make me smile Glaucon. You are afraid that the public will accuse you of recommending unprofitable studies.

Friedman, like Socrates, never failed to remind us of the value of basic research.

HERBERT GURSKY
Superintendent
Space Science Division
Naval Research Laboratory

THESE REMARKS WERE MADE DURING A MEMORIAL SERVICE FOR DR. FRIEDMAN AT THE COSMOS CLUB ON 19 OCTOBER 2000.

Herb Friedman, as a scientist, was one of the best by any measure. The beautiful Herb Friedman room at the Naval Research Laboratory that was dedicated to him on 5 October has a wall to wall layout of his career and stature as a scientist: bibliography, scientific papers, citations, awards, honorary degrees, newspaper clippings, and photographs of Herb with presidents and other heads of state, the pope, famous scientists, and other leading luminaries of the last half century. The display is literally a review of science of this period, its great discoveries, its historic impact, exemplified by Herb's career.

Herb was a multiplier of science in that he opened avenues of discovery to many other scientists by developing new tools and new modes of experimentation, not just for himself but for many others. Astronomers rely on radiation from stars and galaxies to find out about their evolution and dynamics. When Herb started his career they were limited primarily to optical telescopes and photographic plates. Today, thanks to a few pioneers like Herb Friedman, we have added microwave astronomy, infrared astronomy, ultraviolet astronomy, X-ray astronomy and gamma ray astronomy, neutrino astronomy, and space-based astronomy. Because of their work astronomy continues to rank among the most fascinating and productive sciences today.

Such distinction as Herb's in a scientific field is a goal that most scientists aspire to. But Herb had more in mind for his life. He understood that public service could have many dimensions and he dedicated his time and energy and great talent to them as well. I will list a few:

Teacher. Herb was a teacher in the best sense of reaching out to people everywhere through his books, popular articles, and lectures. He wrote and spoke about how scientists think and work, about the exhilaration of discovery, and about the panoramic history of science.

Adviser. Not so visible but of great importance to scientists and the public was Herb's role as adviser (and teacher) to government officials, up to the highest levels. Just think of the damage uninformed policy-makers can cause to science and to the country. Herb did all this in different ways:

1. As a member of the President's Science Advisory Committee
2. As a member of the General Advisory Committee of the Atomic Energy Commission
3. As one of the most senior scientists in the navy
4. As a member of the National Academy of Sciences

As an example, when I was science adviser to President Carter there was a moment in budget discussions when the president said we could not fund both a mission to Halley's comet and a Gamma Ray space-based telescope. Which should we do? I told the president that the scientific community was divided, that the comet was the more glamorous project. I added that Herb Friedman thought that the telescope was the intellectually deeper mission. And that's the way that Carter decided. You can find a letter from the Carter White House to Herb on the wall in the Friedman room at NRL.

Herb and the National Academy of Sciences. NAS has been called the world's most influential advisory group. Election to NAS is one of the highest honors that can come to an American scientist. Only one in two thousand is elected. And add that Herb was one of the most influential members of NAS—so that makes him even more rarified—perhaps one in twenty thousand.

A. He served on twenty-one different boards, commissions, panels—that has to be a record and is a tribute to his wisdom, his experience, and the esteem in which he was held. He was active on what I consider to be two of the most important ones—the Report Review Committee that examines the adequacy and reliability of each Academy and National Research Council report, and also the governing board of the National Research Council, which approves all new projects.

Herb as a citizen-scientist of the world. He understood that science is international in scope—that scientists speak a common language, that they have similar goals, that most have common ethical and moral standards, that they build on each other's work.

B. He was an enthusiastic promoter of international scientific organizations.

C. He was an invited professor, visitor, guest lecturer, scientific collaborator, and organizer of international projects countless times (there is hardly a place in the world that Herb and Gertrude have not visited).

D. He was often one of the first American scientists to gain entry into countries with closed borders.

E. He was a human rights activist working to help scientists in trouble under dictatorial regimes.

Herb and the arts. To fully understand Herb, one must know him also for his involvements with art and music, which in an important sense define him as a person. He had an eye and an ear for the humanities that would have made him just as special in that world, as in science had he followed that other path. Such talent had to be in his genes. This brings to mind a remark of my former MIT colleague, the physicist Victor Weisskopf, when he was asked what gave him hope in troubled times. His answer: Mozart and quantum mechanics. Herb would have given a similar answer. He was as much as anyone a renaissance spirit in the way he blended the different parts of knowledge to help us appreciate the whole. That's one more reason we all esteem him.

Herb's image among scientists. Simply stated, Herb was beloved among scientists as few scientists are. He was generous and always available to help anyone who came to him. He could be tough in his own way, but he never raised his voice, never showed off, never ventured an opinion unless he knew what he was talking about. I was present at many meetings in which he participated, and I can tell you that when Herb spoke everyone listened.

Herb still speaks to us in the sense that his work lives on for future scientists to learn from and to build upon. For all who crossed his path, Herb Friedman remains a model of how to be a creative scientist and a contributing human—a memorable personality for all of us to admire and try to emulate.

Elected 1964; Council 1992–99; Committees: Advisory, The Joseph Henry Papers 1991–2000; Advisory on Election of Members 1997–2000; Magellanic Premium 1988–2000; Meetings 1991–2000; Membership I 1992–2000; Nomination of Officers 1993–2000

Frank Press
President Emeritus
National Academy of Sciences