BIOGRAPHICAL MEMOIRS

Ira B. Bernstein

November 8, 1924–October 8, 2024
Elected to the NAS, 1984

A Biographical Memoir by Peter J. Catto

Figure 1 Ira B. Bernstein, photographer unknown. *Courtesy of Adam Bernstein.*

Ira B. Bernstein was a monumental figure in theoretical plasma physics. Among his three most important foundational contributions is his elegant kinetic theory proof that waves propagating perpendicular to a homogenous magnetic field in the cyclotron range of frequencies are undamped.[1] These important electrostatic waves were subsequently observed to exist and are now referred to as Bernstein modes. During his time at the Princeton Plasma Physics Laboratory (PPPL) he co-authored many other innovative papers in plasma physics, including the original ideal magnetohydrodynamics (MHD) energy principle paper[2] of Bernstein, Ed Frieman, Martin Kruskal, and Russell Kulsrud, which is often thought to be the most highly cited paper in plasma physics. The energy principle's importance continues to this day because of its variational nature and the need for magnetic fusion experiments to satisfy ideal MHD stability to avoid catastrophic plasma loss. Almost as highly cited, is the BGK mode paper by Bernstein, John Greene, and Kruskal,[3] which demonstrated it was possible to find steady state nonlinear phase space solutions of the collisionless Vlasov kinetic equation.

Ira was born on November 8, 1924, and educated in New York City. He earned a Bachelor of Chemical Engineering degree from the City College of New York in 1944 and a Ph.D. in physics from New York University in 1950. His thesis was entitled "Improved Calculations on Cascade Shower Theory." His advisor was Hartland Snyder, who as a student and collaborator of Robert Oppenheimer, had used Einstein's theory of general relativity to show how black holes could form. After college Ira served in the Navy for two years, and from 1948 to 1950 he was Research Fellow at the Brookhaven National Laboratory in Upton, New York.

Upon graduation from NYU, Ira went to work for Westinghouse Research Laboratory in East Pittsburgh, Pennsylvania. There he met a first-generation Italian American artist Gioconda (Gio) Oresti who was then employed designing window displays for department stores—well before the advent of online shopping. In 1955 Ira and Gio were married in New York City. Shortly after, while on another visit to NYC, Gio wrote a check, but had forgotten her ID. The clerk didn't dare accept it, but the manager took one look

at the name Gioconda Bernstein and approved the check immediately by saying no one would ever write a bad check using that name.

In 1954 Ira was recruited to Princeton University by Lyman Spitzer Jr. He and his other distinguished colleagues (Kulsrud, Kruskal, Greene, Frieman, Carl Oberman, John Dawson, John Johnson, Katherine Weimer) hired by Spitzer were appointed as Research Associates on Project Matterhorn, a then secret U.S. government research project on magnetic fusion that started in a former rabbit hutch in 1951. During the 1961–1962 academic year Ira was a Fulbright Scholar at Frascati Laboratories in Italy. Ira and Gio and their two young children, Elisa and Adam, happily adapted to life there and enjoyed all things Italian. With Gio's help, Ira's language skills improved and he took great pride in being able to give a seminar in Italian before leaving Frascati. Shortly after returning to Princeton, he became a Senior Research Physicist at PPPL.

During his time at Princeton, Kruskal and Bernstein also performed the seminal work on understanding the generation of high-energy tails on the electron distribution function referred to as runaway electrons.[4] Their earliest research in this area began as Ira started his Fulbright sabbatical, so he always acknowledged and appreciated the efforts of Martin back in Princeton, while he was enjoying the wines and food of Italy. Ira had a deep understanding of collision operators, including clever ways to derive important limiting forms. With Andrew Lenard, he formulated a simplified Lenard-Bernstein collision operator[5] retaining many of the features of the full Fokker-Planck collision operator. Its analytically more tractable form is often found to provide useful insight. Shortly thereafter, Bernstein and Irving Rabinowitz formulated a theory of spherical and cylindrical electrostatic probes immersed in collisionless plasmas,[6] while earlier he and Theodore Holstein, then a colleague from Westinghouse, published an influential paper on electron energy distributions in stationary discharges.[7] In addition, Bernstein and Surindar Kumar Trehan published a timely and detailed review of plasma oscillations,[8] and with Kulsrud he investigated ion wave instabilities.[9]

Upon leaving Princeton and joining the faculty of Yale University in 1964 as a full professor of applied physics in the Department of Engineering and Applied Science, Ira continued to make pioneering contributions in an extraordinary number of diverse areas of plasma physics. These included, but were not limited to, the quasilinear theory of turbulent plasmas with Folker Engelmann,[10] the relativistic theory of electron cyclotron resonance heating of fusion plasmas with David Baxter,[11] and geometric optics in spatiotemporally varying plasmas.[12] For the brief period in which Russell Kulsrud was also a full professor at Yale, Russell's astrophysical influence was evident. He and Ira published notable work on the explosion of a supernova in a magnetic field. In addition, Ira's well-known expertise in all things variational played a key role in the evaluation of collisional transport coefficients in various collaborations. Some of his other areas of interest included the relativistic treatments of free electron lasers, compressibility effects on the Rayleigh-Taylor instability, the confinement of magnetic mirror trapped particles, and the reduced kinetic description referred to as gyrokinetics in the high flow limit.

In 1982 Ira was awarded the James Clerk Maxwell Prize for Plasma Physics given by the Division of Plasma Physics of the American Physical Society. It annually recognizes outstanding contributions to the field of plasma physics. His citation reads: "For his pioneering contributions to the theory of plasmas. His incisive studies of the physics of waves, stability, and transport have provided essential guidance to a generation of colleagues and disciples." For the associated lecture he presented his latest thoughts on geometric optics.

Ira was elected to the National Academy of Sciences in 1984 as a member of the Applied Physical Sciences section. Recognition by the Academy further highlighted his foundational work on plasma stability, wave propagation, and fusion research, influencing generations of physicists. His profound impact on the scientific community was also recognized by his election to fellowship in the American Physical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science.

Ira was an excellent teacher and lecturer, but was known for being a demanding adviser and grader. He did not contribute to grade inflation at Yale! When he took over and taught the graduate course in applied mathematics in the fall of 1967, he commented at the start of the first lecture, only half-jokingly, that the course was being given at Yale, but the standard was being set at Princeton. He gave no A's in the first semester, and only a couple in the second semester in a class of about 30 first year graduate students. Thereafter, he was referred to by some of the graduate students as "beast Bernstein"—a label he chuckled over, as he was well known for his integrity and for challenging colleagues as well as students. In 1971 he became Director of Graduate Studies in the department. Whenever one of his PhD students graduated, Ira was known to take them aside and say to them "you may now call me Ira"—much to Gio's delight, as she would laughingly check with the student to make sure they had been given official permission!

While at Yale Ira took sabbaticals as a Visiting Professor and Guggenheim Fellow at Imperial College in London in 1969 and as a Visiting Member at the Institute for Advanced Study in Princeton during the spring term of 1973. In 1994 he was appointed as the Carl A. Morse Professor in

Mechanical Engineering and Applied Physics, a chair he held until his retirement in 2004, after which he became professor emeritus. During his distinguished career he served as a plasma physics consultant to RCA in Princeton, from 1960 to 1964; and became a consultant to the United Aircraft Research Laboratory in Connecticut in 1966; to the Los Alamos National Laboratory in 1967; to Lawrence Livermore National Laboratory in 1971; and to the Naval Research Laboratory in 1973. In addition, he served on numerous advisory panels for the U. S. Department of Energy.

Ira and Gio would often invite visiting collaborators to stay with them at their home in Hamden. This arrangement had the wonderful advantage of the marvelous home cooking of Gio, but the disadvantage of having to walk into Yale and back to Hamden at high speed with Ira as this was his principal form of exercise.

Ira died on October 8, 2024, just a month short of his one hundredth birthday. He remained outgoing and articulate with a wonderful sense of humor and impressive memory until the end, even though Gio's death in 2016 had left him without the love and joy of his life during his later years. Ira and Gio's warmth, kindness, and generosity were well known to the frequent visitors to their home where they were thoughtful hosts, lively and fun companions, outrageously competitive Scrabble players, and always a joy and privilege to have as friends.

Ira's demanding and uncompromising drive for excellence and the deepest possible understanding left a lasting mark on his colleagues, collaborators, and graduate students.

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