ics and electrical engineering (1980) and his PhD (1985) from MIT. For his doctoral research he built a free electron laser and made detailed studies of the physics underlying its operation, particularly in the Raman collective regime. He is now working with John Malmberg at San Diego on a cryogenic plasma experiment. The Ramo Award consists of $1500 and a certificate.

obituaries

Harold Grad

The plasma physics community and the scientific world suffered a profound loss upon the death of Harold Grad on 17 November at the age of 63. Only 12 days earlier, his eminent achievements had been recognized by the award of the James Clerk Maxwell Prize of The American Physical Society, at ceremonies he was unable to attend (see page 85). He will be remembered, not only for his scientific accomplishments, but for his intense devotion to the cause of good science. His intolerance of slipshod thinking and his tenacity in pursuit of the truth are legendary, nonetheless he made great efforts to help those who lacked his skill, insight and knowledge. He was gentle toward his students and junior associates, and he was enormously exciting to work with. His stimulation and unstinting willingness to share carried far beyond his close associates. Few of us will forget his quick wit, for he was often wonderfully funny.

Grad began as an electrical engineer, receiving his degree from Cooper Union during World War II. After that, while working as an engineer in a defense industry, he took evening graduate courses at the Courant Institute (then the Institute for Mathemaics and Mechanics) at New York University. With Richard Courant's encouragement and help, he left his job to complete his graduate work at NYU where he pursued his entire professional career, achieving full professorial rank early. He founded the magnetofluid dynamics division of the Courant Institute in 1956 and remained its director for 25 years.

Grad was a founder of the Society of Engineering Sciences. He was an active member of the New York Academy of Sciences, and served on its Board of Governors (1978-81). He was elected to the National Academy of Sciences in 1970. Much of Grad's energy was devoted to the activities of APS. He found it amusing that he was the only living person who had been chairman of two society divisions, the Fluid Dynamics Division and the Plasma Physics Division.

Courant, in trying to capture the essence of Grad's genius, said that Grad had the rare ability to understand and interpret the physical world as a mathematician. It is also true that, as a physicist, Grad had the unusual talent to find the mathematics that most appropriately models the physical world. This he did, working first in fluid dynamics, statistical mechanics and kinetic theory, to prepare himself, finally, to be a master of the budding science of plasma physics.

The basic quality of Grad's work was already visible in his 1948 doctoral thesis on the kinetic theory of rarefied gases. In this seminal work, Grad explicitly introduced the concept of a hierarchy of models interpolating between kinetic theory and fluid dynamics, and he exploited the concept to go a level higher than the Navier–Stokes system, to the so-called thirteen-moment equations. Thus, Grad made his mark early as an architect of general systems. Within a few years he was recognized as a leader in kinetic theory. His 1958 monograph in the *Handbuch der Physik*, *Principles of the Kinetic Theory of Gases*, laid down new foundations for the subject.

In 1958, he presented in outline a derivation of the Boltzmann equation as a singular limit. This outline was finally filled in rigorously in 1975 by Oscar Lanford (Institut des Hautes Études Scientifiques, Vures-Sur-Yvette, France). Also in statistical mechanics, he contributed fundamental clarifications of the concepts of entropy and molecular chaos. In kinetic theory, his two major papers in 1963 on the asymptotic theory of the Boltzmann equation, together with his earlier work, have been a springboard for most further development. It is said that Grad was invited to participate in the development of the hydrogen bomb; instead he made a conscientious decision to work on the peaceful use of fusion energy. In 1955, he joined the fusion power program, then classified under the code name Project Sherwood. He became a preeminent plasma physicist, masterfully deploying his method of looking at the field through a hierarchy of models from magnetofluid dynamics through guiding center fluid and guiding center plasma to fully kinetic models. Much of this development is summarized in his 1967 monograph, *The Guiding Center Plasma*. He was an avid practitioner as well as a generalist: He introduced the curvature criterion for magnetohydrodynamic stability, and from that developed the first known stable plasma configurations—cusped geometries—which formed the basis of a patent by Grad and Kurt O. Friedrichs (Courant Institute).

Grad's work touched on virtually every aspect of plasma physics: He systematically explored variational methods, formulating and applying them to problems of equilibrium and stability, for both fluid magnetic and plasma models. (An example is the magnetic-well principle underlying the stability of cusped geometries.) In orbit theory, he investigated nonadiabatic orbits in a cusped magnetic field and he fully examined the consequences of the pathological long term behavior of orbits in toroidal geometries. He developed the concept of collisionless shock prior to its confirmation by experiment. In equilibrium theory, Grad pointed out the necessity of symmetry for the mere existence of exact toroidal equilibria, and he was the first to seriously consider the appearance of mathematical pathology in toroidal geometries. In addition he created a new approach to transport that permits two- and three-dimensional problems to be solved without an enormous increase in difficulty over one-dimensional problems. Grad based this work on his theoretical development of, and numerical experimentation with, a new type of equation, the "queer" differential equation, which he introduced in 1970.

Toward the end, Grad concentrated his efforts on the development of algorithms and codes for solving transport problems that arise in the magnetic fusion program. Despite his flagging energies, he pursued this work with the same youthful zest and desire to expand the boundaries of knowledge that marked his entire scientific career. Overcoming the difficulties caused by his ill health, he still maintained his concern and efforts for those around him, and he continued to support and advance the interests of his junior colleagues. The many who benefited from his wisdom and caring will miss him keenly.

ALBERT A. BLANK
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Clifford Keith Beck

Clifford Beck died on 17 April 1986 after a protracted illness. He was born on 12 April 1913 in Salisbury, North Carolina, and received his undergradu-

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ate education at Catawba College. He did graduate work at Vanderbilt University and the University of North Carolina at Chapel Hill, and was granted a PhD in physics by the latter in 1943.

During World War II Beck did research on the enrichment of uranium isotopes in the Manhattan District's SAM laboratories of Columbia University. After the war, the staff and facilities were moved to the Oak Ridge Gaseous Diffusion Plant, and he joined Dixon Callihan and Elizabeth Johnson in criticality studies for the safe handling and storage of fissionable material, which involved placing variable masses of U^{235} or Pu^{239} on a variety of lattices with variables spacings.

At this stage of the development of nuclear energy, it was widely assumed that all nuclear reactors had to be government owned and operated in facilities of the Atomic Energy Commission. Beck questioned the necessity of this policy and succeeded in persuading AEC to license the construction on a university campus of a research reactor owned and operated by the university. In 1949 he went to North Carolina State University as professor and head of the department of physics. There he directed the construction and operation of the first university research reactor, which was used to train undergraduate and graduate students in the new field of nuclear energy. Participants came from many locations for what became a pioneering and international study program.

While at North Carolina State, Beck was instrumental in organizing the American Nuclear Society and was a founding member and director of the organization. In 1953 he was elected to the board of directors of the Oak Ridge Institute of Nuclear Studies (now Oak Ridge Associated Universities), and was vice president from 1954 to 1956.

In 1956 the Atomic Energy Commission separated the regulatory from the promotional functions for nuclear energy, and Beck was appointed chief of the reactor hazards evaluation branch of the new division of licensing and regulation. Later, as deputy director of regulation Beck contributed significantly to establishing safety standards in the nuclear industry. When the Nuclear Regulatory Commission was established as an independent agency, Beck transferred from AEC to NRC and distinguished himself particularly in its international program.

From 1960 to 1969, Beck served as a member of Maryland's Montgomery County board of education, serving as its president in 1967. He was instrumental in founding the Maryland State Board of Community Colleges and served as its chairman from 1968 to 1979.

Both of us were colleagues of Beck at Columbia during the war. As members of the dwindling community of those who had the thrill of participating in the Manhattan Project, we mourn his death and shall miss his companionship in the future.

WILLIAM G. POLLARD
Oak Ridge Associated Universities
DONALD B. TRAUGER
Oak Ridge National Laboratory

Henry Levinstein

Henry Levinstein, professor of physics at Syracuse University, died on 21 June 1986 at the age of 66.

Levinstein was born in Themar, Germany, and came to the United States in 1938. He did his undergraduate and graduate work at the University of Michigan, eventually receiving his PhD in 1947 under the sponsorship of H. Richard Crane. That same year he joined the physics department at Syracuse University.

His research was in solid state physics. At first his principal interest was in understanding and developing intrinsic photoconductive infrared-sensitive detectors, including PbSe, PbTe, InSb and GaAs. For some years, his research group was the only source of detectors whose sensitivity extended to the 5-micron region. These detectors were made available to workers in astronomy, environmental science, medicine and the military.

Subsequently he concentrated his efforts upon extrinsic infrared detectors, primarily the various doped-germanium types. Levinstein and his students greatly elucidated the physics of these materials, and many of his students continued to work in this field at various universities and industrial laboratories throughout the country.

Levinstein served as chairman of the New York State section of The American Physical Society. He was chairman of the Third International Photoconductivity Conference in 1969 and he edited its conference reports. He was also a longtime chairman of the detector group of IRIS and was president of the Syracuse chapter of Phi Beta Kappa. He served as an adviser to Texas Instruments and General Telephone and was a member of the technical advisory board of Aerojet General, and for many summers he taught a course on photoconductivity at the University of California at Santa Barbara.

One of his continued interests was "gadgets," and he developed it into a course on the physics of toys, which attracted hundreds of undergraduates each time it was given. He became a noted speaker on the subject and gave numerous, entertaining after-dinner talks at APS meetings in the United States and Canada.

Levinstein was very popular with his undergraduate students, many of whom considered him a friend as well as a teacher and kept contact with him long after graduation because of his warm and gentle nature. His fellow faculty thought highly of him as a person and as a scientist.

NATHAN GINSBERG
H. W. BERRY
Syracuse University
Syracuse, New York

Joyce Alvin Bearden

Joyce Alvin Bearden, professor emeritus at The Johns Hopkins University and a major figure for over half a century in x-ray research, died on 28 July after a period of ill health. He was 82.

Bearden was born in Greenville, South Carolina, in 1903 and graduated from Furman University in 1923. He received a PhD from the University of Chicago in 1926 and remained there as an instructor for three years. In 1929 he joined the Johns Hopkins faculty, advancing to a professorship in 1939. During World War II, Bearden worked with the National Defense Research Committee on the variable time proximity fuze, an association that not only took him to Europe as a Colonel in the US Army but also led to his founding, with D. Luke Hopkins, Merle Tuve and Lawrence Hafstad, The Johns Hopkins Applied Physics Laboratory. After the war he assumed the directorship of the radiation laboratory at Johns Hopkins, a position he held until 1955. From 1947 through 1949 he also served as chairman of the physics department.

Bearden's 50-year scientific career began in the early years of quantum mechanics and terminated only near his death. Best known is his work dealing with fundamental constants and accurate x-ray wavelengths. But one finds as well several efforts at conceptual clarifications, such as his first paper (published jointly with Arthur H. Compton) on the effect of a surrounding box on the spectrum of scattered x rays; in this category is also to be found a paper with John A. Wheeler on x-ray line strengths. Nevertheless, it is the body of his work concerned with exact measurement that is most widely appreciated and for which he will be long remembered. Within this domain there were two periods of intense productivity which, though separated by thirty years, pro-