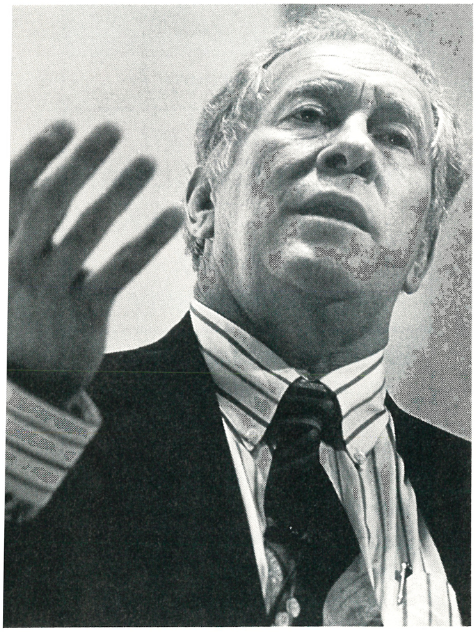

David Norman Schramm

His work on the r-process—the buildup of the heaviest elements through rapid capture of neutrons—was influential, and his introduction of the concept of a model-independent mean age for the heavy elements enabled radioactive elements such as uranium, thorium, rhenium and osmium to be used to place realistic constraints on the age of the universe. In two papers with James Lattimer—the first in 1974—he developed what later because known as the Lattimer–Schramm model for the tidal breakup of a neutron star near a black hole. Originally put forth as a possible site for the r-process, the Lattimer–Schramm model turned out to be the first discussion of a now-popular model for the enigmatic cosmic gamma-ray bursters. He and David Arnett pointed out the importance of the discovery of the neutral-current weak interaction of neutrinos for the collapse and explosion of massive stars in supernovae.

In cosmology, Schramm found a field large enough to match his scientific appetite and accommodate his creative energies. In 1974, in one of his first and most cited papers on cosmology, he and J. Richard Gott III, James Gunn and the late Beatrice Tinsley laid out the case for a low-density universe. Their arguments are still valid and used today. Among the first to appreciate the richness and importance of the connection between elementary particle physics and cosmology, he, perhaps more than any other, helped to establish the now-vibrant interdisciplinary field of particle cosmology. For years, Schramm was bullish on cosmology, foreseeing—even boldly predicting—the present golden age of cosmology, in which an abundance of high-quality observations would test bold ideas, such as inflation and cold dark matter, that are based upon the particle physics connection.

Although his contributions to cosmology were manifold, Schramm's most widely recognized work was on Big Bang nucleosynthesis—that is, the sequence of events that led to the production of deuterium, helium-3, helium-4 and lithium a few seconds after the Big Bang. Opening with a seminal paper written with Hubert Reeves, Jean Audouze and Fowler in 1973, Schramm made the case for the Big-Bang origin of these four light elements. Over the years, Schramm and his many collaborators went on to exploit Big Bang nucleosynthesis as a crucial test of the Big Bang model, as the most accurate means of determining the density of ordinary matter and as a powerful probe of elementary particle physics. Of these applications, he was proudest of the Big Bang limit on the number of light neutrino species—fewer than four—that originated in a 1977 paper he wrote with Gary Steigman and Gunn. This limit was verified in 1989 by experiments at CERN and the Stanford Linear Accelerator Center that measured the properties of the Z boson.

Equally important, however, was the conclusion reached by Schramm and various collaborators—again based upon Big Bang nucleosynthesis—that ordinary matter falls far short of accounting for the observed amount of matter in the universe. This fact is the linchpin in the case for the bulk of the dark matter being elementary particles left over from the earliest moments. It is fitting that the primordial abundance of deuterium, which Schramm viewed as the light element best suited for accurately determining the baryon density, was measured shortly before his death in high-redshift hydrogen by David Tytler and his student Scott Burles. (In fact, Schramm's last published paper was an article in *Reviews of Modern Physics* on the implications of Tytler and Burles's measurement.)

Over the years, Schramm wrote papers on a remarkably diverse set of topics with an equally diverse group of coauthors. His papers addressed the solar neutrino problem, isotopic anomalies in meteorites, the origin and propagation of ultrahigh-energy cosmic rays and phase transitions in the early universe. With particle theorist John Ellis, he speculated that the sudden demise of the dinosaurs might have been triggered by a nearby supernova, and with particle experimentalist Leon Lederman, he wrote the acclaimed book *Quarks and the Cosmos* (W. H. Freeman, 1990), a popular account of the connections between cosmology and particle physics.

Beyond his own important contributions, Schramm helped to make science happen. A unique and multidimensional mentor, he encouraged his students and postdocs with unbounded generosity, providing ideas and support throughout their careers. He defied geographical bounds by sharing the latest scientific news with colleagues of all ages all over the world. An excellent matchmaker, he stimulated new collaborations connecting researchers in different subfields with complementary expertise.

Schramm's energy, enthusiasm and positive attitude were legendary. It seemed that he attended or organized every meeting, served on or chaired every committee and wrote or coauthored every paper. As the chair of the National Academy of Sciences' Board on Physics and Astronomy, he led the ten-year review of physics that is now in its final stages. During his twenty-year association with the Aspen Center for Physics, astrophysics became a major focus of the center, and as chairman of the board, he led the fund-raising drive that resulted in three new buildings.

Schramm lived life with the same verve—he was an avid mountaineer and expert skier, he had a passion for flying, and he was a devoted husband and father.

To all who knew him, Schramm seemed like a primeval force of nature, which makes his premature death seem all the more unreal.

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Gertrude Scharff Goldhaber

Gertrude Scharff Goldhaber, a renowned nuclear physicist and the first woman PhD hired by Brookhaven National Laboratory (BNL), passed away in Patchogue, New York, on 2 February after a long illness.

Born in Mannheim, Germany, on 14 July 1911, Trude Scharff began her physics career in 1935, when she earned a PhD from the University of Munich. From 1935 to 1939, she lived in England, where she held a postdoctoral position at the University of London's Imperial College.

Having married Maurice Goldhaber, who was then a physics professor at the University of Illinois, she immigrated to the US in 1939 and became a research physicist in the same department as her husband. There, in 1942, she discovered that spontaneous fission is associated with the emission of neutrons—a discovery kept secret until World War II ended. In 1948, she and Maurice established the identity of beta particles with atomic electrons.

That same year, she was made a research assistant professor. However, her further advancement was blocked by the university's antinepotism rules. To avoid them, she and Maurice moved in 1950 to BNL. An associate physicist at first, she was promoted to physicist in 1958 and senior physicist in 1962.

From the early 1950s onward, Trude directed her scientific research toward systematizing the properties of nuclear levels across the entire periodic table. It was a time of rapid development in both experimental techniques and nuclear structure theory. Independent particle and collective motion models were proposed to describe nuclear excitations, but the regions of applicability of each class of model were largely unknown. For instance, the 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 that time was devoted to resolving these apparent contradictions. In 1953, she demonstrated the existence of shell structure in excited nuclear states by conducting 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 finding that the excitation energy increases strongly at the shell closures. A few years later, she and Joseph Weneser noted that the ratio of excitation energy of the second excited state to the first in nuclei in the region where $38 < N < 88$ significantly differs from that in the adjacent region where $90 < N < 108$. The value in the lower region is near the ratio of 2 identified with phonon excitation in spherical nuclei, whereas the value in the upper region is near $10/3$, which signals an abrupt change in the spacing of excited states characteristic of rotating deformed nuclei.

GERTRUDE SCHARFF GOLDHABER

In 1957, Trude reported the remarkable isomerism in the deformed nucleus, hafnium-180, with its implied retardations of 10^{16} and 10^9 for the E1 and E3 transitions, respectively, thereby dramatically verifying the predictions of K forbiddenness in electromagnetic transitions of deformed nuclei.

Over many of the following years, Trude with various collaborators developed the phenomenological variable moment of inertia model 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 $10/3$.

Taken as a whole, Trude's work played an integral part in unfolding the story of nuclear structure, alerting experimentalists to important regions of the periodic table and confronting theorists with the realities of nature. For her contributions to nuclear physics, she was elected to the National Academy of Sciences in 1972 (becoming only the third female physicist so elected).

In addition to her science, Trude also had a major impact on life at BNL. In 1960, she started the Brookhaven lecture series, which continues today to introduce BNL scientists and others to research by their lab colleagues. She was a founding member of Brookhaven Women in Science in 1979, and she often lent her energies to education and to attracting women to the sciences.

Having retired in 1977, Trude continued her association with BNL as a research collaborator until 1990. She also held adjunct professorships at Cornell University and Johns Hopkins University in the 1980s. She served on several committees, including the American Physical Society's committee on the status of women in physics, the National Research Council's human resources committee on the education and employment of women in science and engineering and the National Academy of Sciences' committee on human rights.

Trude made important contributions to science and was an inspiration to many women as a pioneer in a field dominated by men. She was devoted to improving science education at all levels, and was an avid hiker, swimmer, tennis player and skier. Her contributions to both BNL and the science community were important and long lasting.

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John Reginald Richardson

John Reginald Richardson, who, over his long career, was one of the dominant figures in cyclotron development, died in Fremont, California, on 25 November 1997 after a lengthy illness. He was 85. His many achievements include the first demonstration of phase stability, the first synchrocylotron and the first sector-focused cyclotron.

Born in Edmonton, Alberta, Reg lived in Vancouver, British Columbia, until he reached the age of 10, when his family immigrated to the US. He took his bachelor's degree at UCLA, where Glenn Seaborg remembers him as the top physics student of their class of 1933.

Reg then went to the University of California's Berkeley campus, where, as Ernest Lawrence's last graduate student, he received his PhD in physics in 1937. After a year as a National Research Council fellow at the University of Michigan, he was appointed an assistant professor of physics at the University of Illinois—in both places continuing his PhD studies of nuclear structure and bringing his Berkeley expertise to bear on the two universities' newly constructed cyclotrons.

In 1942, after the US entered World War II, Reg returned to Berkeley to develop calutrons for the electromagnetic separation of uranium for the Manhattan Project.

When the principle of phase stability was discovered independently by Vladimir Veksler in 1944 and Edwin McMillan in 1945, it was thought at first that its application to cyclotrons required moderately high energy ion injection. However, exploiting his calutron experience, Reg was able to show that 1–5% of the ions emerging from an ion source could be captured