stable isotopes within an object; images dependent on NMR relaxation times; images of organisms that show soft structures and tissues; in vivo study of malignant tumors based on relaxation times; images displaying chemical compositions or diffusion constants; NMR zeugmatography of solids; electron spin resonance zeugmatography; and internal structures, states, and compositions of microscopic objects. In fact, Paul soon demonstrated many of these applications, including the first image of a living animal (a 4-mm-diameter clam), use of paramagnetic contrast agents, and chemical-shift imaging.

Paul made many further advances in NMR imaging at Stony Brook and at the University of Illinois at Urbana-Champaign, where he moved in 1985. During the past few years, Paul returned to his early interest in the origin of life—this time not in a hypothetical silicon-based biology but in the real world of organic carbon compounds. He described the potential role of molecular imprints and the ways that free-energy-driven processes can lead to molecular evolution.

A book could be written about Paul's curiosity-driven research, his innovative approach to problems, and his many accomplishments only hinted at here. Those of us who knew him as a valued and warm colleague, the next generation of scientists who were inspired by his brilliance and enthusiasm, and the millions who have benefited from the application of his work in medicine are fortunate that Paul Lauterbur passed our way.

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Kenneth Ingvard Greisen


RUSS HAMILTON/CORNELL UNIVERSITY

Kenneth Ingvard Greisen

Kenneth Ingvard Greisen, professor of physics emeritus at Cornell University, died of cancer in Ithaca, New York, on 17 March 2007. Greisen's career in experimental cosmic-ray physics extended from his graduate work at Cornell to innovative experiments in the 1960s and 1970s. He will be most remembered for his realization that the cosmic microwave background limits the high-energy end of the spectrum of cosmic-ray protons that travel astronomical distances.

Born in Perth Amboy, New Jersey, on 24 January 1918, Greisen graduated from Franklin and Marshall College in Pennsylvania in 1938. He entered Cornell for graduate work in physics, where he was the first US graduate student of Bruno Rossi. His 1942 PhD thesis was titled "Intensity of Cosmic Rays at Low Altitude and the Origin of the Soft Component." His joint 1941 review article with Rossi, "Cosmic-Ray Theory" in *Reviews of Modern Physics* (volume 13, page 240), was a standard for many years.

From 1943 to 1946 Greisen was a member of the group of physicists who worked on the Manhattan Project at Los Alamos. As one of the leaders of the detonation team, he was an observer at the Trinity test on 16 July 1945. His eyewitness report of that world-changing event is an important historical record. His comment "My God! It worked!" was typical of him.

Greisen returned to Cornell in 1946 as an assistant professor and thus initiated his 40-year career as a physics researcher, physics educator, mentor of students and postdocs, and public servant to the university community.

Greisen's investigations of cosmic rays ranged from using detectors on high mountains and far underground in salt mines to using balloons to send gamma-ray detectors into the high atmosphere. With a gas Cherenkov detector in a 1971 balloon flight, he and his colleagues observed gamma rays from the Crab Nebula that were synchronized with its pulsar.

After the 1965 discovery of the cosmic microwave background, Greisen (and independently Georgii Zatsepin and Vadim Kuzmin) realized that the number of cosmic-ray protons at energies above 6×10^{19} eV is greatly reduced due to interactions with the microwaves. This GZK cutoff would virtually eliminate the highest-energy protons that travel cosmological distances.

Due to the extremely low rate of air showers with energies above 10^{19} eV, detectors of enormous size are required to detect cosmic rays above the GZK limit. Greisen and his group at Cornell designed a method of observing air showers that uses the fluorescent light created as the shower proceeds through the atmosphere. Near Ithaca in 1964–71, they observed the night sky with arrays of phototubes arranged in a "fly's eye" configuration. This method was significantly refined and improved by physicists at the University of Utah and became the basis for the High Resolution (HiRes) Fly's Eye experiment. In March 2007 the HiRes collaboration reported observation of the suppression of cosmic rays with energies above the GZK limit (see PHYSICS TODAY, May 2007, page 17). Fluorescence detectors are one of the two principal components of the Pierre Auger Observatory, currently nearing completion in Argentina to study cosmic rays near and beyond the GZK limit.

Along with Cornell colleagues Philip Morrison and Hans Bethe, Greisen contributed to the work of the MIT-based Physical Science Study Committee (the source of the PSSC high-school physics curriculum) in the late 1950s. In 1969 he presided over a team from the Cornell department of science education and a group of physics colleagues working on a major revision of a 400-student introductory physics course. The result was an innovative, self-paced, auto-tutorial course that retains that format today. His service to the wider Cornell community included a term as university ombudsman from 1975 to 1977 and a term as dean of the university faculty from 1978 to 1983.

In 1971 Greisen cofounded the high-energy astrophysics division of the American Astronomical Society, and he was its first chair. He was elected to membership in the National Academy of Sciences in 1974.

In both the world of physics and the wider world, Greisen displayed a deep sense of responsibility to the people around him. His students and postdocs remember him as a brilliant physicist who was kind and generous and who encouraged them by respecting their competence. At a time when very few women attempted careers in physics, Greisen was exceptionally supportive of those who did.

Greisen enjoyed the outdoors and music; he played the flute and sang in choirs. Following his retirement in 1986, his persistent concern for the welfare of others led him to do volunteer work with various local organizations that served people in the community who were marginalized by age or economic circumstance.

Greisen combined his unfailing attention to the needs of those around him with a career in experimental physics at the top of his field. Cosmic-ray physics continues to be shaped by his accomplishments and those of his younger colleagues.

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Chauncey Starr

EPRI

Chauncey Starr

Chauncey Starr, veteran of the Manhattan Project, champion of the peaceful uses of atomic energy, originator of the academic discipline of risk analysis, and founder of the Electric Power Research Institute, died on 17 April 2007. The previous day, at his 95th birthday celebration held at EPRI, Chauncey held forth on his life experiences and lessons learned. He was in fine fettle. The following morning before leaving for his office at EPRI, as he had been doing ever since his "official" retirement 30 years previously, he took his usual short nap after breakfast. But on this day he didn't wake up. It is hard to conceive of a more graceful, indeed elegant, departure after a long and fulfilling career of service and contributions to his country and the welfare of its people. During my 11 years at EPRI, I was honored and privileged to have Chauncey as my mentor, collaborator, and dear friend.

The second son of Russian Jewish immigrants, Chauncey was born 14 April 1912 in Newark, New Jersey. It is family legend that at birth his parents named him after a relative in Russia, but the attending officials at the hospital "translated" the Yiddish into "Chauncey" and it stuck. Educated in the local public-school system, he earned a BS in electrical engineering at Rensselaer Polytechnic Institute. His 1935 PhD thesis in physics at RPI was on the thermal and electrical properties of rectifying copper oxide junctions. I used to kid him that if he had accidentally gotten some calcium impurities into his samples, he might have discovered today's family of high-temperature cuprate superconductors.

After RPI he joined Percy Bridgman's group at Harvard University as a research associate to work on the thermal transport properties of metals at high pressure, one of the most difficult condensed-matter experiments to carry out given the confounding background of containment vessels and thermometry. Chauncey devised a differential method capable of much more accurate determination of the thermal diffusivity (the ratio of thermal conductivity to specific heat) of metals in the presence of such addenda. This was an especially important advance at the time, inasmuch as Bridgman had published work suggesting that the Wiedemann–Franz law may not hold in metals under pressure; Chauncey was able to show with his new technique that Bridgman's conclusion resulted from systematic errors in the previous experiments. To claim that Chauncey saved Bridgman from not receiving his future Nobel Prize may be a stretch, but he certainly rescued his boss from major embarrassment. In one of those inexplicable coincidences of life, 25 years later in 1962, I undertook my doctoral work in that same high-pressure group at Harvard, and several of my fellow students were still employing the measurement methods Chauncey had designed.

From Harvard, Chauncey went on to a similar postgraduate position at the MIT Magnet Laboratory; there he added cryogenics and magnetic measurements to his portfolio of experimental skills. His publications between 1938 and 1941 dealt principally with the low-temperature magnetic properties of transition-metal halides. He still kept in contact with Harvard, and John Van Vleck's influence on his work is clear.

Word of Chauncey's technical and leadership skills spread throughout the then-small community of American physicists. In 1942, while at the Bureau of Ships heading a group of engineers working on electronic detection of mines, he was invited to join Ernest Lawrence's staff at the University of California Radiation Laboratory. Lawrence's intention, largely unknown to Chauncey at the time, was to "train" him in the principles of cyclotron resonance for eventual reassignment to the calutron, or "racetrack," uranium-235 separation effort in Oak Ridge, Tennessee, which was having great difficulty reaching its production goals. Chauncey was subsequently transferred to Oak Ridge to serve as Lawrence's liaison and directed a group of several hundred engineers that made crucial improvements to the yields of the beta calutrons; by the spring of 1945 Oak Ridge had produced enough ^{235}U to arm the Little Boy weapon used against Hiroshima.

After the war Chauncey transferred to Clinton Laboratories at Oak Ridge to participate in the nuclear power reactor design efforts led by Eugene Wigner and Alvin Weinberg. In 1946 he joined North American Aviation, and in 1955 he formed and became president of a new division, Atomics International, to pursue commercialization of the generation of electricity from nuclear power. In collaboration with Walter Zinn at Argonne National Laboratory, Chauncey explored the peaceful application of atomic energy to the generation of electricity, an effort he considered his most important contribution. In 1966 he left Atomics International to become dean of engineering at UCLA; six years later he founded the Electric Power Research Institute.

Chauncey also made substantial contributions to the discipline of risk analysis while at UCLA and established an environmental division at EPRI over the vigorous opposition of several utility CEOs. At heart, though, he remained always a physicist.

For his accomplishments, Chauncey received the American Physical Society's 2000 George E. Pake Prize and numerous other awards and recognition, including honorary degrees, membership in national and international academies, medals from heads of state, and fellow status in professional societies. But I know his most personally satisfying recognition came near the end. Secretary of War Edwin Stanton said about Abraham Lincoln after his assassination, "Now he belongs to the ages." For Chauncey, in a sense, the ages returned to him: He was able to witness the rebirth of interest in nuclear power in the US, the fruit of his younger days, which had lain abandoned for so many years.

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