

## KENNETH INGVAR D GREISEN, 1918–2007

Cornell University Emeritus Professor of Physics, Kenneth I. Greisen died on March 17, 2007 of cancer at the Hospicare residence in Ithaca New York. He was 89 years old. Prof. Greisen was well-known for his participation in the Manhattan Project at Los Alamos and for his many contributions to the study of cosmic ray physics. More quietly, Prof. Greisen also made significant contributions to the teaching of Physics at the high school and university levels. He was of service to the Cornell and Ithaca communities in many ways both during his university career and after his retirement.

Kenneth Ingvar d Greisen was born in Perth Amboy, NJ on January 24, 1918 to Signa and Ingvar d Greisen. Ken's father was a building contractor who died at a relatively young age following a heart attack. Ken attended Wagner College, Staten Island NY in 1934-1935. Abandoning religious studies, Ken transferred to Franklin and Marshall College in Lancaster PA where he ran on the track team and graduated summa cum laude with the prestigious Henry S. Williamson Medalist award in 1938.

Ken then entered graduate school in physics at Cornell University. He recalled that, as a graduate student in theoretical physics with no knowledge of experimental physics, he had the "temerity" to ask the eminent Italian physicist Bruno B. Rossi "if I would be welcome as a student under him; and he needed one, no matter how ignorant. So he took me and for a couple of years I was his only student." Together they constructed experimental equipment to study the anomalous atmospheric attenuation of mesotrons. This last of Rossi's mountain experiments on mesotron decay yielded the quantitative verification of the relativistic dilation of time intervals and an improved estimate of the mean life of mesotrons at rest (*Physical Review*, 61, 675-679, 1942). Rossi and Greisen also published a review article in 1941 on "Cosmic-Ray Theory" in *Reviews of Modern Physics* (13, 240-209), which became a standard for many years. Ken's Ph.D. thesis entitled "Intensity of Cosmic Rays at Low Altitude and the Origin of the Soft Component" (*Physical Review*, 63, 323-333, 1943) appeared along with several related articles in volumes 61 and 62 of *Physical Review* (1942). During this very productive period, Ken also married my mother, a biology graduate student at Cornell.

Upon graduation, Ken and Betty moved to Los Alamos NM where he joined the Manhattan Project. He was among the leaders of the group that designed and built the explosive charge that initiated the nuclear reaction in the first atomic bomb. He drove the detonators to the bomb test site, getting an infamous speeding ticket in Socorro in the process, and was the next to last person up the tower preparing the test detonation. He witnessed the July 16, 1945 Trinity explosion from 10-miles away, providing an eyewitness account which is an important historical record. After the explosion, in a remark typical of him, he is widely quoted as saying "My God, it worked!" Following the war, Ken, along with Hans Bethe and other scientists, sent a letter to the President strongly advocating only



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non-military use of nuclear research. Ken's son (1944) and daughter (1946) were both born in Los Alamos.

Ken and family returned to Cornell University and Ithaca NY where he remained, except for sabbatical periods, for the rest of his life. He spent the next years studying cosmic rays and the showers of particles produced by them in the atmosphere and various absorbers. He constructed an array of large plastic scintillators atop a dozen Cornell University buildings, allowing the directions of air showers to be determined by relative timings in addition to measurements of the total intensity. He also took detectors 600m underground in a salt mine beneath Cayuga Lake near Ithaca. The minimum energy for a muon to penetrate to that depth is of order  $3 \times 10^{11}$  eV. In summers through 1953, the whole family would move to Colorado for high-altitude studies on Mt. Evans, the location of the highest-altitude paved road in the U.S. A wide variety of detectors were placed at three elevations, in Idaho Springs (2600m) where we lived, at Echo Lake (3260m), and at the very top (4300m). These studies even attracted the interest of, and an article in, *Life Magazine*.

In the early 1960s, Ken's attention turned to the extremely high-energy end of the cosmic ray spectrum. In early 1966, he realized that cosmic ray protons at energies above  $6 \times 10^{19}$  eV will interact significantly with the extremely low energy photons of the Cosmic Microwave Background, which had recently been discovered. This energy is the threshold energy for the photo-production of pions ( $p + \gamma \Rightarrow N\pi$ ). If the sources of such extremely high energy cosmic rays are at cosmological distances, this interaction should cause a sharp cutoff in the cosmic ray spectrum beginning at this energy. (The mean free path of

such protons with respect to collisions with relic photons is a few Mpc, limiting the distance to their sources to about 50 Mpc at most.) This effect has been named the GZK cutoff after Greisen's paper (Phys Rev Let 1966, 16, 748-750) and an independent paper, submitted slightly after Ken's paper was published, by Georgi Zatsepin and Vadim Kuzmin (JETP Letters 1966, 4, 78-80). Ken's paper also predicted a small dip in the cosmic-ray spectrum at energies of  $10^{18} - 10^{20}$  eV due to pair production by the thermal photons.

Even without a cutoff, cosmic rays of energies in excess of  $10^{19}$  eV are very rare and, thus, require a detector of very large area to obtain a significant event rate. Fortunately, cosmic rays of this energy produce an air shower that causes the Earth's atmosphere to fluoresce, making the Earth itself the detector. Beginning in the early 1960s, Ken and his group developed instruments to measure this fluorescence and implemented them in the hills surrounding Ithaca. The "fly's eye" configuration of phototubes in their detectors attracted a cover article in *Sky & Telescope* (October 1967). Ken took a sabbatical in Spring of 1966 at the University of Utah, where the skies are darker and clearer. Beginning around 1970, the Utah group has extended and improved on the Cornell ideas, creating the High Resolution (HiRes) Fly's Eye detector. Two weeks before Ken's death, the Utah collaboration reported on AstroPh observations of the high-energy cosmic ray spectrum clearly showing the GZK cutoff (*Physics Today*, May 2007) as well as the predicted dip at lower energies. The Pierre Auger Observatory, currently nearing completion in Argentina, will also use fluorescence detectors as one of two methods of studying the high-energy end of the cosmic-ray spectrum.

In the late 1960s, Ken's research interests extended to the field of gamma-ray astronomy. These led in time to the construction of large-area, gas-Cherenkov telescopes for the detection of astronomical sources of high-energy gamma rays. The Cornell 100-inch telescope was a structure 6.1m high and 2.9m in diameter with a series of materials designed to discriminate against cosmic-ray nuclei and select gamma rays in the appropriate energy ranges. This telescope was flown by a very high-altitude balloon from Palestine TX on several occasions. It provided the first detection of gamma rays from the Crab Nebula pulsar at energies above 160 MeV and particularly above 600 MeV (ApJ, 184, 571-580, 1973).

As his studies became more astronomical in nature, Ken joined the AAS in 1966, the same year I went off to graduate school in astronomy. Two years later, Ken was named to the AAS organizing committee that established the High Energy Astrophysics Division (HEAD) of the AAS. Ken was selected as HEAD's first Chair for 1970 and 1971. Ken was also on the organizing committee that helped establish IAU Commission 48 on High Energy Astrophysics also in 1970. He was subsequently elected to the National Academy of Sciences in 1974. Election to membership is one of the highest honors that can be accorded to a scientist and recognizes scientists who have made distinguished and continuing achievements in

original research.

For all the time and energy spent on research, Ken probably devoted more than half of his efforts to the teaching of Physics at all levels. Following the Sputnik surprise of October, 1957, he contributed to the work of the Physical Sciences Study Committee at MIT which was the source of the PSSC high-school physics curriculum. This advanced curriculum had a major impact throughout the world on the teaching of Physics. At Cornell, Ken developed and taught for many years a course entitled "The Revolution in Physics, 1900 to 1925" which was an in depth introduction to all of modern physics intended to separate students who should become physicists from those who were merely interested. I can personally attest to the difficulty of that course and the skill with which my father taught it. In 1969, he presided over a team from the Physics and Science Education Departments to completely redesign the teaching of introductory physics at Cornell. The result was an innovative, self-paced, auto-tutorial course that retains that format today (*American Journal of Physics*, 45, 1082-1088, 1977). Ken regularly concerned himself with the overall structure of Physics courses at Cornell, assigned himself early hours for his courses so that his students could take popular courses in other departments, and heavily supported the careers of those faculty who distinguished themselves as teachers.

Ken was the faculty adviser to legions of undergraduates, many of whom owe their continued college careers to Ken's diligence. He was very proud of his graduate students who included, in no particular order, William Kraushaar, David Koch, Alan Bunner, Peter Landecker, Fred Ruckdersbel, Alan Zabell, Jerry Pine, Dick Davisson, Lowell Bollinger, Stewart Bennett, John Delvaille, Everett Palmatier, Byron Roe, W. Pak, Yehude Eisenberg, Garland Branch, W. W. Brown, Hakki Ogelman, Paul Albats, James Ahlstromp, and Alec S. McKay. Post-Docs included Edith Cassel, Brian McBreen, John Earnshaw, Seinosuke Ozaki, Goro Tanahashi, and Paul Barrett. Close colleagues in the early years included Giuseppe Cocconni, who later became Director of CERN in Geneva, and his wife Vanna Cocconni-Tongiorgi, as well as Cornell faculty including Hans Bethe and Phillip Morrison.

The affection his colleagues felt for Ken was perhaps best illustrated when the Ozakis named their first child Kenichi. Don Holcomb, retired Professor of Physics at Cornell writes "He was a wonderful colleague, with his quiet mix of high competence and thoughtful human values." Martin Harwit writes "At Cornell, Ken was always held in the highest esteem for his competence and for his great integrity. My colleagues and I in the Astronomy department asked him to serve as our Chair even though he had not been a Department member simply because we had such great trust in him. I hope you will find solace in knowing the high esteem in which all of us held Ken as a scientist and a man of character." Murray Campbell wrote "Ken became a model for me of brilliant and incredibly strong physicist who was kind and generous. I've tried to live up to his ideals in my

liberal arts college teaching.” Peter Landecker writes “I remember Ken called me to his office and told me I had won a NASA Fellowship. It was to pay my graduate tuition and fees in full and give me a generous living allowance as well. There were no strings attached (no need to pay it back or work on NASA projects). I was amazed. I told Ken that there must have been a mistake as I did not apply for this Fellowship. Ken calmly told me he had applied for it on my behalf!” Paul Albats writes “He had a great patience and a way of giving people second chances; I was certainly a beneficiary. He gave you a feeling that he respected your technical competence; he was willing to discuss your proposal on your level. I never saw him use his high position to win a technical argument.”

In addition to teaching, Ken also held official positions of considerable responsibility at Cornell. He was university Ombudsman in the period 1975 to 1977. He was Chairman of the Astronomy Department from 1976 to 1979. He then served as Dean of the Faculty from 1978 to 1983. Ken was proud of the sincere standing ovation he received as he stepped down from that position. Current Deans of the Faculty still hold him in high regard as they told me at his memorial service. Ken was granted an Emeritus professorship in 1984 and retired in 1986.

Ken greatly enjoyed music and the out of doors. Throughout his life, he played the flute and the recorder and attended many of the concerts available at Cornell and Ithaca College. He sang for many years in the Unitarian Church choir and, in later years, the Presbyterian Church choir and Senior Chorus. He greatly enjoyed hiking, boating, golf, and other outdoor activities, maintained a cottage on Piseco Lake in the Adirondacks for 15 years, and, at Kendall, took up the bicycle for exercise.

Ken viewed retirement as a reason to leave university life behind, but not to cease providing service to those about him who needed help. In retirement, Ken drove small buses to provide transportation to the elderly and infirm, helped with Meals on Wheels, provided income tax consulting, and served on the board of the Senior Center, among other things. In his later years, he engaged in a nearly daily “hobby” of writing checks to numerous charities. Of course, he also found time to take month-long winter vacations to Kauai and to Florida. Ken was one of the first residents in Kendall at Ithaca, which was the retirement village of choice for the Cornell Physics Department.

Ken was preceded in death by his parents, younger brother Sigurd Greisen, older sister Agnita Dupree, first wife of 34 years Elizabeth Chase Greisen, second wife of 20 years Helen Wiltberger Greisen, and stepson Bruce Wiltberger. He is survived by his long-time companion Tommie Bryant of Ithaca NY, daughter Kathryn Greisen of Columbus OH, son Eric Greisen of Socorro NM, step children Heather Wiltberger of Marshall VA, Paul Wiltberger of Arlington WA, and Lois Wiltberger of Arlington MA, and several step-grandchildren.

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