Pittsburgh Hosts 1994 March APS Meeting

In March 1994 Pittsburgh hosts the American Physical Society March Meeting for the first time in over three decades. We expect 5,000 participants, making this the largest physics conference in the United States. Join us this year; explore the latest physics research and discuss it with your former teachers and colleagues. Mark the dates Sunday, March 20 - Friday, March 25, 1994, on your calendar and let us know that you will attend the conference.

This conference focuses on the physics of solid and liquid materials. We anticipate strong attendance from Carnegie Mellon’s Physics, Chemistry and Engineering departments. Many of our faculty and graduate students, and even some undergraduates, will speak about their own research. Hot topics covered include buckyballs, high temperature superconductors, magnetic materials, polymers and biophysics, with practical applications in materials science, and electrical and chemical engineering. Other sessions address national science policy, employment prospects for young scientists and avenues for scientists to contribute to economic growth.

Carnegie Mellon will coordinate educational outreach in conjunction with the conference. We address the needs and interests of Pittsburgh area high school teachers and students through a day-long program. And two workshops on the Sunday prior to the conference feature the introductory undergraduate physics teaching program of our Center for the Development of Educational Computing.

The Pittsburgh Supercomputer Center, operated jointly by Carnegie Mellon, University of Pittsburgh and Westinghouse for the National Science Foundation, will offer a tour of their facility at the Westinghouse Energy Center. The tour features the CRAY and Connection Machine computers used by many of the scientists attending the conference.

We invite you and your spouse to a reception on Wednesday, March 23 from 5:30 - 7:30 p.m. in the Allegheny Room of the Vista Hotel. Carnegie Mellon alumni and faculty, representatives of local industries and prominent scientists will attend. If you will join us, please return the attached card by Friday, February 18. That date is also the APS pre-registration deadline. Keep this newsletter as a reminder of the time and place for the reception. We look forward to seeing you in March.
Dear Alumni and Friends of the Physics Department:

Once again I have many departmental topics to report to you. Sadly, I must first advise you of the deaths of Richard E. Cutkosky, Buhl professor of physics, and Clarence Zener, university professor of physics.

Dick Cutkosky passed away in June, after an illness that was with him for many years. He held both undergraduate and graduate degrees from Carnegie Institute of Technology. When I first met Dick in 1964, he was already an established star at the age of 36 in theoretical particle physics. I would characterize him as a man devoted to his family, to our university, to his colleagues and students and to Pittsburgh. We could always look to him for sound advice and for some good humor. His absence is already evident in the department. I will propose to the physics faculty that the alumni award, which is presented annually to an undergraduate at commencement, be renamed and from here forward be called the Richard E. Cutkosky Alumni Award. I hope that you, the alumni who donated the funds to establish this award, will concur with me.

Clarence Zener died in July. Most of you know of one result of Zener's work: the Zener diode. Few of you will have had direct contact with him, since he did not teach courses in the department. However, he was involved with members of the department in research, most notably in the area of Ocean Thermal Energy Conversion.

Obituary of Cutkosky and Zener appear in this newsletter.

On May 16, 1993, the department graduated 37 new physicists. There were 20 undergraduates, eight master of science graduates, and nine Ph.D. graduates. Our most current information is that six will enter the industrial world and eight will enter the academic world. I wish them the very best in their chosen careers.

This year at commencement the alumni award was presented to two very deserving undergraduates: Lisa Milan and Randall Telfer. Both graduated with university honors and both exhibited the breadth of knowledge, leadership and departmental service the faculty look for in selecting the award winners. Congratulations to Lisa and Randy for this special recognition.

One of our graduate students, Jarneel al Khafiz, won the university's first Merck Fellowship. This fellowship provides full tuition plus a generous stipend.

The 1992-93 academic year marked the full retirement of three members of the faculty: Joseph Artman, Simeon Friedberg and Helen Goldberg. Joe Artman has been a member of the department since 1964 and was jointly a member of the department of electrical engineering. He maintained an active experimental program in condensed matter physics and had thesis students in both departments. Sim Friedberg joined the department in 1953 and was its chairman from 1973 to 1980. His research has been in low temperature condensed matter physics and many of you have passed through his very demanding tutelage in obtaining your advanced degrees. Helen Goldberg, senior lecturer in physics, joined the department in 1977. Helen was an outstanding teacher in the department, having won the Julius Ashkin teaching award last year. In addition to teaching, Helen made important contributions in the advising of minority students. On behalf of the department, I want to thank Joe, Sim and Helen for many years of devoted service to the students and faculty of this university; we wish them the very best in the future. I expect we will still see something of them working in the department in spite of having retired.

Lincoln Wolfenstein has chosen to reduce his teaching load to half time beginning in August of 1993. Lincoln joined the department in 1949 and continues to have an outstanding career in weak interaction theory and related areas. His recent work on the flux of electron neutrinos from the sun has generated much interest in cosmology and particle physics.

The department is happy to announce to you the addition of four new faculty members. Associate Professor Jeffrey Peterson comes to us from Princeton University. Jeff is an experimental astrophysicist currently interested in the 2.7 degree background radiation anisotropy and who acquires his data at the South Pole. Jeff is the first astrophysicist in the department; we hope to add more in the near future. Assistant Professor Curtis Meyer, an experimentalist in our medium energy program, comes to us from University of Zurich, Zurich, Switzerland. Martin Savage, a native of New Zealand, comes to us from the University of California at San Diego. Martin is an assistant professor and a particle theorist. Finally, George Klein joined us during the past year as lecturer in physics. George came to us from LaGuardia Community College of the City University of New York, Long Island City, N.Y., in January and has ably taken over the teaching and advising role for the minority students formerly held by Helen Goldberg. I want to welcome these faculty members to the department and wish them very successful careers with us.

Professor Brad Keister is spending the 1993/94 academic year at the National Science Foundation where he will be a contract officer in theoretical nuclear physics.

This fall we admitted 13 new graduate students into the department; three
New Faculty Join the Department

As noted by Bob Kraemer in The Chairman's Column, we have four new members on the department faculty. Following are brief introductions to the newcomers.

**George Klein**
Dr. Klein came to Carnegie Mellon in January 1993 on a joint appointment between the Carnegie Mellon Physics Department and the minority retention program (CMAP). At Carnegie Mellon he teaches in the introductory physics courses, works in collaborative initiatives with the CMAP staff and teaches an introductory course during a summer bridge program.

Klein was born and raised in Caracas, Venezuela. He has a Ph.D. in physics from New York University where he worked in general relativity theory. He has taught physics at The Cooper Union and the City University of New York in New York City, Bloomfield College in New Jersey and more recently at Mt. San Antonio College in Los Angeles. He is married and has a five-year-old daughter.

**Curtis Meyer**
Professor Meyer did his undergraduate studies in physics and mathematics at Oregon State University (B.Sc. 1982 with highest honors). His graduate work in physics was done at the University of California at Berkeley (M.S. 1984, Ph.D. 1987). From 1987 until 1993, he held a postdoctoral research position at the University of Zurich, Zurich, Switzerland. During this time, he worked at both the European Center for Particle Physics (CERN) and the Deutsches Elektronen-Synchrotron (DESY). He joined the physics faculty of Carnegie Mellon in 1993 and his current research interests are experimental medium energy particle physics. He is presently involved in work at CERN and the Brookhaven National Laboratory.

**Jeffrey B. Peterson**
Dr. Peterson did his undergraduate work at the University of Illinois, and earned his Ph.D. in physics in 1985 at the University of California at Berkeley. He held appointments as instructor, then assistant professor at Princeton before coming to Carnegie Mellon. In 1987 he was granted a Presidential Young Investigator Award by the National Science Foundation. Peterson's research interests are in the areas of cosmology, including cosmic background radiation (CBR), dark matter and baryogenesis; gravitational radiation; gravitational lensing; and laboratory tests of quantum electrodynamics. Currently he serves as principal investigator for a group of 10 physicists building CBR anisotropy telescopes. His observations of CBR are carried out at a research station in Antarctica. Peterson is married, with three children.

**Martin John Savage**
After earning his B.S. and M.S. degrees at the University of Auckland, New Zealand, Dr. Savage went to the California Institute of Technology where he completed his Ph.D. in theoretical physics in 1990. He held postdoctoral fellowships at Rutgers University and the University of California at San Diego before joining the faculty at Carnegie Mellon. Savage's research is in theoretical elementary particle physics.

As usual, I invite each of you to communicate with us and tell us what you are doing or what's new in your lives. If you are in Pittsburgh, please come to my office for coffee and some relaxation.
The Carnegie Mellon Buckyball Project was conceived in November 1991 to investigate buckminsterfullerenes and related compounds. Buckminsterfullerenes, also known as "buckyballs" or "fullerenes," are small hollow carbon clusters with shapes reminiscent of a geodesic dome. The first student research began in January of 1992 and has continued year-round since then. This project is aimed at fostering cross-disciplinary research and collaborations in the theory, synthesis, characterization and properties of fullerenes and fullerene-based solids. This project is aimed also at having a significant involvement in undergraduate research projects. Four Carnegie Mellon faculty members are involved in the project: Professor Sara Majetich, physics; Professor Michael McHenry, MSE; Professor Stuart Staley, chemistry; and Professor Joseph Artman, physics and ECE.

The Carnegie Mellon Buckyball project had several objectives when it started in January of 1992: (1) to introduce the students to the process of research, (2) to develop students' professional skills, (3) to teach students how different techniques from a variety of disciplines are used to understand new materials and (4) to do forefront research in a few target areas in the Buckminsterfullerene field.

The research course has a weekly meeting where students give presentations in which they survey current literature and hear presentations by the various faculty members on topics relevant to current and future research plans. They also attend seminars in the Chemistry and Physics departments which have invited some of the important researchers in the field to describe their work. Each student writes a research-related term paper and gives an oral presentation on his or her research at the end of the semester.

Students are broken up into groups in which they participate in specific components of the Buckyball research. Currently we have students working on (1) synthesis by arc welding with carbon electrodes, (2) synthesis of endohedral fullerenes (buckyballs with atoms inside) and nanocrystalline magnetic carbides (larger particles encased in giant buckyballs), (3) separation of buckyballs using column chromatography, (4) magnetic separation of fullerenes and nanocrystals, (5) production of solid C_{60} thin films by vapor deposition, (6) doping of C_{60} films with alkali metals by evaporation to make superconductors, (7) single crystal growth of pristine and doped fullerene-based crystals, (8) SQUID magnetometry and (9) optical spectroscopy.

Physics students who have participated in the Carnegie Mellon Buckyball Project include Sara Chae '92, Mrinal Iyengar '93, Sam Minter '93, Steve Kendrish '95, Dana Moudry '95, Byron Sinor '93, Jim Williams '94, Brian Bailey '94, Paul Lu '93, Cliff Tanaka '94, Shelley Anna '95, Michael Foley '95, Shannon Lernow '96 and Jennifer Newbury '94.

We gratefully note that the Carnegie Mellon Small Undergraduate Research Grant (SURG) program has been a generous supporter of our group. Most of its funding comes from outside Carnegie Mellon, and it benefits from alumni support.
The two largest electron-positron accelerators in the world, SLC and LEP\(^1\), have devoted the past four years solely to producing as many Z\(^0\)'s as possible (several million thus far). Simultaneously, five international collaborations of more than 300 physicists each are involved in investigating the decay products of the Z\(^0\). These collaborations are operating detectors each of which carries a typical price tag of $100 million and took more than half a decade to build. A Carnegie Mellon group consisting of my faculty colleagues, Arnold Engler, Tom Ferguson, Bob Kraemer, Roger Sutton and myself are members of one of these collaborations, named L3, at LEP. With funding from a U.S. Department of Energy grant, we contributed to the L3 experiment the design and construction of one of the detector systems—the so-called "luminosity monitor." Since the startup of data taking in 1989 we have been in charge of the operation of this detector and of part of the overall data analysis in L3. We have three postdoctoral associates and two graduate students permanently based at CERN, supplemented by faculty traveling frequently between Pittsburgh and Geneva. I spent a sabbatical year at CERN in 1989/90; Tom Ferguson did the same in 1990/91 and Arnold Engler was there for half a year in 1992.

You will never encounter a Z\(^0\) particle in everyday life. Neither is there any practical application for it in sight: it will not cure cancer, and it is useless as a weapon! So, why should it deserve so much attention by scientists and funding agencies alike?

The answer in "sound bite" form—given the scope of this short article—is that from the Z\(^0\) we learn about the forces at work between the elementary particles and about the nature of those forces as they were at the time the universe was very young, shortly after the big bang. Moreover, we can find out how many types of elementary particles exist in the universe—the modern version of determining the number of elements in the periodic table.

According to our current understanding the fundamental building blocks of matter are quarks and leptons. The lightest quarks, u (up) and d (down) make up the protons and neutrons in ordinary nuclei. The lightest leptons are the familiar electron, e, and the electron-type neutrino, \(\nu_e\). These four are grouped together into the first "family" or "generation." Experiments done in the past 30+ years have revealed the existence of two more such generations which have very similar properties as the first, except that each new generation is much heavier than the previous one. Only the neutrinos of each generation have zero or at most, very small masses. We make use of this feature in our experiment to measure the number of generations.

The Z\(^0\), postulated by Glashow, Weinberg and Salam in the 1960s, was discovered in 1983. It is the heavy partner of the photon in the celebrated "Standard Model" of unified electron-weak interactions. When a Z\(^0\) comes into existence in an accelerator it can—just like a photon—decay through "pair production" of any electrically charged particle in the table shown and the antiparticle thereof: electron-positron, quark-antiquark, muon-antineutrino, etc., but because of its "weak charge" the Z\(^0\) can also turn into any neutrino-antineutrino pair. The rate for each individual decay channel is well known, and the respective partial widths add up to the total width of the Z\(^0\). So the recipe for counting the number of generations is amazingly simple: measure the total width and the partial width of all "visible" channels. The difference is then the "invisible width" which must be due to decays into the neutrinos which our detector cannot track. Dividing this "invisible width" by the known partial width per neutrino type then gives the number of neutrino generations and thereby the number of fundamental constituents.

Our latest experimental result for this number is 3.00 ± 0.05 which excludes a fourth generation of quarks and leptons "by 20 sigmas." The periodic table of the elementary particles is complete at three generations!

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1 The SLC at Stanford is a two-mile long "linear collider." LEP at the European Laboratory for Particle Physics, CERN, near Geneva, Switzerland, is a circular collider with a circumference of 17 miles.
Richard E. Cutkosky

Richard E. Cutkosky, the Buhl professor of physics at Carnegie Mellon University, died on June 17, 1993, following a stroke. He was 64 years old.

Cutkosky took all his degrees at Carnegie Institute of Technology (now Carnegie Mellon University), receiving his Ph.D. in 1953 under the direction of Gian-Carlo Wick. After a year at the Niels Bohr Institute, Cutkosky joined the faculty of Carnegie Institute of Technology where he was named the Buhl Professor in 1963. He returned to the Bohr Institute as an NSF Research Fellow for 1961-62 and was a fellow of Churchill College in Cambridge for 1968-69.

Much of Cutkosky’s work concerned the analytic properties of scattering amplitudes. Following the work of the Russian physicist Lev Landau, Cutkosky derived general formulas for the discontinuities across cuts in Feynman amplitudes. The Cutkosky rules remain a basic tool in elementary particle physics calculations.

The major concern of Cutkosky during the 1960s was the understanding of the excited states of baryons. He worked on supermultiplet symmetry, on the possible bootstrap origin of these symmetries and the inter-relations among the deviations from the symmetry. The knowledge of baryon excited states derives mainly from pion-nucleon scattering and Cutkosky’s interest in these states led him to explore methods of analyzing scattering data. Making use of the analytic properties of scattering amplitudes derived from general principles, Cutkosky developed a conformal transformation that could be used to improve the usual partial wave expansion method. For many years Cutkosky and his associates applied his methods to provide a comprehensive analysis of all pion-nucleon scattering data. This led to the finding of many baryon resonances that serve as major tests of the constituent quark model. Indeed until he died Cutkosky served as a contributor to the Review of Particle Properties and also as an editor of the p-N Newsletter.

Most recently Cutkosky, his students and post-docs have been concerned with non-perturbative QCD. In contrast to the standard lattice methods, Cutkosky developed a hyperspherical expansion that retained the spherical symmetry of the theory. This work provided interesting insights into the problem of confinement and the properties of glueballs.

Dick was a dedicated teacher, an active environmentalist and served as chairman of the science faculty for 1989-91. In spite of serious ailments in recent years Dick continued his work until his last few weeks. He will be missed by his colleagues at the university and his associates around the world.

Clarence M. Zener

Clarence M. Zener, a world-renowned physicist, died of heart failure on July 2, 1993.

Zener, 87, was a professor in the physics department at Carnegie Mellon whose work expanding the theoretical study of solid-state physics often was years ahead of its technological applications.

The Zener diode, a voltage regulator developed in the 1950s that is used in modern computer circuitry, resulted from a paper explaining the breakdown of electrical insulators that Zener published in 1934.

“He was very well known for early work he did on the properties of solid materials... some of which led to the Zener diode,” said John Fetkovich, the associate head of the physics department and assistant to the president of the university.

“The most remarkable thing about him is how he could be given a problem he hadn’t faced before and, with speed and accuracy that is very rare, come to understand it... and see the way to deal with it,” Fetkovich said.

“Even in recent months, at that age (87), he was as sharp as most scientists that I know and he continued to be intellectually curious and active... Just being with him and seeing how he worked actually helped me,” Fetkovich said.

Herbert A. Simon, who won the Nobel Prize in economics in 1978, said Zener was “a very pleasant and congenial person... he was very well liked.”

“He certainly was one of the outstanding scientists on our faculty,” said Simon, a former dean of the Carnegie Mellon Graduate School of Industrial Administration.

Zener was credited with helping to develop geometric programming, a standard technique useful in mathematical studies as well as practical engineering and business administrative problems.

He was internationally recognized for introducing a field of scientific study with his work on internal friction, the process by which the energy in a vibrating metal is converted to heat as the vibration subsides. He also pioneered the concept of ocean energy using the temperature gradient in the ocean while avoiding environmental problems found in other methods.
Physics Department Reception

The department annually holds an open house and cocktail reception for alumni during the homecoming weekend. The photographs on this page show some of those who attended the reception last October. Although we don't yet know when the next homecoming weekend will be, be assured that we will have open house, followed by a reception, on that Friday. You (and a guest) are most cordially invited to attend whether or not you intend to participate in the homecoming festivities. Watch your mail next summer for notification of the homecoming schedule.

Hubert Aaronson, R.F. Mehl professor of metallurgical engineering and materials science, called Zener "a rare, strange genius" in the winter 1985 edition of Carnegie Mellon Magazine.

The Material Research Society in 1982 called him one of the "most fundamental and original of any 20th century scientists."

Before joining the Carnegie Mellon faculty in 1968, Zener had been dean of science for three years at Texas A&M University. He joined Texas A&M after retiring from Westinghouse Electric Corp. Research Laboratories where during his 14 years he was director of research and director of science.

Zener was a physics instructor at Washington University in St. Louis from 1936-37 and at the City College of New York from 1937-40. He was an associate professor at Washington State University from 1940-42, then a principal physicist at the Watertown (Mass.) Arsenal during World War II. After the war, he taught at the University of Chicago until 1951.

His honors included the Von Hippel Award of the Materials Research Society, the Bingham Award of the Society of Rheology, the Wetherill Medal of the Franklin Institute and the Albert Souvere Achievement Award and the Gold Medal of the American Society for Metals.

A native of Indianapolis, Zener graduated in 1926 from Stanford University and received his doctorate in physics in 1929 from Harvard University. He also studied at the University of Leipzig.

(This article is from an obituary that appeared in the Pittsburgh Post-Gazette, July 3, 1993.)

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