Eugene D. Commins

1932–2015

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
Persis S. Drell

NATIONAL ACADEMY OF SCIENCES

EUGENE DAVID **COMMINS**

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By Persis S. Drell

Eugene David Commins, Professor Emeritus at the University of California, Berkeley, passed away September 26, 2015 after a brief illness. Gene, as he was known to most of his colleagues, was a physicist, a gentleman and a beautiful person. Known by generations of students as an inspiring teacher he was widely respected for experimentally attacking extremely difficult problems of fundamental and outstanding importance. He was admired and loved by the students and colleagues who had the good fortune to interact with him over his career. In 2015, the Berkeley physics department established the 'Eugene D. Commins Chair in Experimental Physics' in his honor.

Childhood and early years

Gene was born in 1932 in New York City and spent his early years there before the family moved to Princeton, New Jersey when he was a young teenager. His mother, Dorothy Commins, was a concert pianist and an author. She made her recital debut at the age of 12 and had an active piano career for five decades. Gene would tell stories of sitting under the piano and listening to her practice as a child. Gene's father, Saxe Commins, started life as a dentist but writing was his passion. He became the senior editor at Random House in 1933; a position he held until his death in 1958. Saxe Commins worked with some of the most influential and important writers of the 20th century, including Gertrude Stein, W. H. Auden, Sinclair Lewis, William Carlos Williams, William Faulkner and Eugene O'Neill, among many others.

Gene was named after his godfather, the playwright Eugene O'Neill and he knew Albert Einstein as a family friend and neighbor. Faulkner would come to Gene's Princeton home to work with Saxe. Gene remembered Faulkner sitting at the kitchen table working on the manuscript of *A Fable* and how his father helped William Faulkner through the Nobel ceremony the year he won the prize.

The Columbia physics department was brimming with excitement and discovery in the 1950's. The faculty included I. I. Rabi, C. H. Townes, Polykarp Kusch, C. S. Wu, T. D. Lee, Jack Steinberger, and Leon Lederman, among many others.

Artistic as a child, Gene applied to both an art school and to Bronx School of Science for his secondary education. He was admitted to both on the strength of his exams and grades at the science school and the strength of his artistic portfolio at the art school. He ended up deciding on a career in science but he continued to paint for his entire life. At 13, when he was starting at Bronx High School of Science, Gene had the good fortune to have a great math teacher, Julius Hlavaty. Gene described him as

> *an extremely energetic Czechoslovak who had emigrated to the US in the late 1930s to escape from Hitler. Hlavaty had the ability to electrify his students, and he made a very significant and lasting impression on me. More than anything else, I learned from his example that mathematics is an elegant and beautiful edifice—like a great work of art.*[1]

At Swarthmore as an undergraduate, Gene was drawn to math, but he also enjoyed summer jobs working in a machine shop as well as repairing old 1930's automobiles. His curiosity about nature and how things worked started to draw him toward physics. After graduating in 1953 with honors in math and physics, Gene was persuaded to go to graduate school in physics at Columbia by his brother-in-law Bill Bennett, who had just recently married Gene's sister and was himself a graduate student at Columbia at the time.

The Columbia physics department was brimming with excitement and discovery in the 1950's. The faculty included I. I. Rabi, C. H. Townes, Polykarp Kusch, C. S. Wu, T. D. Lee, Jack Steinberger, and Leon Lederman, among many others. It was a time of tremendous excitement with the development of modern quantum electrodynamics following the discovery of the anomalous magnetic moment of the electron and the discovery of the Lamb shift. Charles Townes was inventing the ammonia maser and laying the foundation for lasers. Lee and Yang predicted parity violation in the weak interaction in 1956 and Wu and her colleagues observed parity violation in the beta decay of polarized cobalt-60 nuclei shortly after. Gene would regale his graduate students through the generations with stories from his Columbia years. One favorite was overhearing a conversation between a graduate student and Polykarp Kusch the day that

Kusch was awarded the Nobel Prize. The graduate student had a molecular beam oven in his hand and was asking Kusch, his advisor, how to repair it. Kusch cut him off saying "Don't bother me with that now. Don't you know I've just been awarded the Nobel Prize." Startled, the student dropped the oven to the floor, where it smashed, and said to Kusch, "Who, you?" to which Kusch responded "Your data will have to be very precise!"

Research career

Gene was a physicist's physicist. He had exquisite taste in physics and he went after problems that excited him. He had a deep command of the field, a prodigious memory, and incredible breadth. He was a student of all areas of physics and was fearless in his pursuit of exciting science, changing fields and learning new technologies as needed. In a world of increasing specialization, he was a generalist.

Gene's physics career began at Columbia where his formal thesis advisor was Kusch but Gene always credited Robert Novick, a postdoc at the time, with teaching him how to do experimental physics. Gene wrote:

> *I worked day in and day out for years with Robert Novick....Novick was a superb experimentalist with a great deal of practical, nuts and bolts engineering experience, and a tremendous capacity for sustained, effective hard work. To this day, I think I learned more from him than from anyone else about how to do experimental physics, and I shall always be grateful to him.*[2]

Even in his early days at Columbia, Gene was becoming known for having good judgment in selecting problems to work on, inventing novel experimental tools as needed and attacking the problems with a degree of thoroughness that set him apart. Gene's PhD work at Columbia pioneered atomic beam resonance experiments with ions to study fundamental properties of short-lived ions and nuclei. He developed a technique for the study of the hyperfine structure of short-lived isotopes produced in an accelerator and then directly transferred in gaseous form to an atomic beam apparatus where transitions are subsequently measured.

His first publication was an outgrowth of the original Lamb shift measurements and was the first atomic beam resonance experiment ever done with ions. Along with Novick, he measured the hyperfine structure of the $2S_{1/2}$ state of singly ionized ^{3}He. By using the ionized atom, they could extract nuclear and electrodynamic information cleanly because the wave functions of the hydrogen-like system are known with much greater precision.

His development of a novel detector also allowed him to place an upper limit on the nuclear magnetic moment of ^{6}He. He then extended the atomic beam magnetic resonance method to study the nuclear spin and hyperfine structure of ^{15}O.

The atmosphere of terrific excitement at Columbia in the 1950's influenced Gene deeply, particularly the discovery of parity violation. Gene wrote:

> *Naive though I was, I had the feeling that there was something very beautiful and mysterious about parity violation; it was a very large and striking effect, obviously very fundamental, but it had gone almost completely unnoticed by the whole world of physics until Lee and Yang brought it to life. Lots of people, including myself, had the following obvious thought: how many more such striking and important phenomena lie unnoticed before our very eyes? Parity violation must have made a very powerful impression on me, because while I did not consciously intend it to be so in the beginning, virtually every experiment I did for the next 40 years had something to do with parity and weak interactions.*

It was also at Columbia where Gene first met Erwin Hahn who was at Watson Laboratories, and was a young adjunct professor at Columbia. They became lifelong friends, quartet playing partners, and Berkeley colleagues. At Columbia, Gene also met Eyvind Wichmann who was a fellow graduate student and followed Gene to Berkeley and remained a close colleague and friend.

Gene stayed at Columbia for two years as an instructor and in 1960 he was recruited to the atomic beams group in the Berkeley physics department where he remained on the faculty until his retirement in 2001. From his first days as an assistant professor until he became emeritus, Gene's professional course was unwavering. He built difficult, intricate equipment to do experiments that probed important and fundamental physics. In designing experiments, he drew on a deep understanding of theoretical physics that guided him as he attacked problems in new ways, and he often did the necessary theoretical calculations to allow for clean interpretation of the results himself. He was never a prolific publisher, but he developed the reputation that every paper he authored was unique in its quality and impact on the physics community. He liked to operate in a small group that included just himself, occasionally a postdoc and a few graduate students, and to publish in an unhurried manner when the experiments were fully completed.

At Berkeley, Gene immediately started to build experiments that expanded on the techniques developed at Columbia for rapid transport of radioactive elements created at Lawrence Berkeley National Lab's 88-inch cyclotron to his atomic beam apparatus where they could be analyzed. He initially focused on ^{19}Ne and ^{35}Ar, using the technique to study the beta decay asymmetry and nuclear magnetic moments of those nuclei, but the ultimate use was for a series of sensitive tests of time reversal invariance in the beta decay of ^{19}Ne. He and a graduate student also executed an elegant demonstration of quantum entanglement by observing the correlation of the polarization of the two photons emitted in a cascade decay of calcium.

Gene's fascination with the weak interaction broadened throughout the 1960s. In 1973 he published an elegant textbook based on course notes that explored both the theory and experimental validation of the weak interaction as it was known up to that point. And then the physics world changed almost overnight with the discovery that same year of weak neutral currents in neutrino nucleon scattering.

The decade of the 1970s will go down in the history of physics as one of the great periods of enlightenment. Underpinning a wealth of experimental discoveries was a renormalizable gauge theory that unified the weak and electromagnetic interactions and was powerfully predictive. After the discovery of weak neutral currents, Gene's research program pivoted to focus on a key prediction of the new theoretical framework: a search for parity non conservation in atomic systems.

Weak neutral currents were a necessary consequence of the unified electroweak interaction. Their observation in neutrino nucleon scattering was important but could not distinguish among several plausible implementations of the underlying model. The simplest gauge theory, the Glashow-Weinberg-Salam model, predicted that a tiny parity non-conserving effect should be manifest in atomic systems. The effect arises from interference between the neutral-weak and electromagnetic interactions that couple an atomic valence electron to its nucleus. Groups at several institutions began work on the extremely difficult optical atomic experiments to try to see the effect.

The challenges were multi-fold. A Z^3 enhancement of the effect made heavy atoms attractive targets but complicated the interpretation of the results. Gene's group chose thallium for its atomic simplicity (one valence electron) and accessibility to lasers that were within developmental reach. Gene and his students did the necessary theory, tested their calculations with measurements, developed the laser technology and ultimately measured the effect. For over a decade Gene vigorously pursued this line of research.

Eugene Commins in the lab with Larry Hunter and the author circa 1980.
(Photo courtesy of Lawrence Berkeley National Laborartory.)

Along the way he developed an incredibly popular course on gauge theories of weak interactions that became a new book, *Weak Interactions of Leptons and Quarks*.

By the late 1980's Gene was starting to think about what to do next. The parity non conservation experiments were winding down but he realized that he could use the expertise built up in those experiments to search for a time-reversal violating electron electric dipole moment. An intrinsic electric dipole moment requires violation of both parity conservation and time reversal invariance and could be induced by radiative corrections. Within the standard model, which by this time was very well established, such an effect is too small to access experimentally. But many extensions of the standard model predicted potentially measureable values. The electron electric dipole moment limits achieved by Gene's group over a decade of hard work are a triumph of insight, ingenuity, and just plain hard work. The two seminal papers from this work published in 1994 and 2002 are among Gene's most highly cited papers.

Gene became professor emeritus in 2001. Colleagues had recognized his distinction in research by electing him a Fellow of the American Physical Society, the American Association for the Advancement of Science, the American Academy of Arts and Sciences, and in 1987, the National Academy of Sciences. He wrote:

> *After about 15 years of effort, we recently completed a lengthy experimental search for the electric dipole moment of the electron. This quantity is of interest in connection with CP violation and extensions to the standard model of particle physics. The experimental methods were those of low-energy atomic physics: atomic beams, laser spectroscopy, optical pumping, and radio-frequency magnetic resonance. We did not find a non-zero EDM, but our upper limit on it is very small, and can be used to place tight constraints on various extensions of the standard model, for example supersymmetry. At this point, I have done the best I can on this type of research and coincident with retirement I now leave it, in the hope that younger researchers will find new methods to advance it further.*[4]

And indeed, the limits have continued to improve in the 15 years since Gene left the lab.

Teaching career

While Gene has many legacies in physics, his role as a teacher stands out. His courses were works of art. Whether he was teaching introductory physics, physics of music, his famous graduate quantum mechanics course or, in the late 70's, a course on the Standard Model of Weak interactions, he elucidated the subjects he taught with a stunning clarity. And his generosity with his time in helping students at all levels, his patience in explaining things clearly, his enthusiasm for the subject he was teaching are legendary. Generations of Berkeley graduates and undergraduates, literally thousands of students, were taught by Gene, and loved him.

Gene's prowess as a teacher was evident as soon as he entered the classroom. He was formally recognized as an outstanding teacher in 1963 while still an assistant professor when he received the University of California distinguished teaching award. In his nomination letter the physics department chair at the time, Burton Moyer, stated that "we have rarely seen a young man who has moved so quickly from the time of his appointment into the role of significance in our departmental teaching.…He brings…a wholesome enthusiasm, characteristically sound ideas, and a real skill in communicating with students in the classroom."[5] By the time of his promotion to full professor in 1968, Gene was widely recognized as one of the best teachers in the department at all levels.

The respect for Gene's spectacular teaching was evident everywhere. Faculty would routinely sit in on his advanced courses to learn a new subject. Students passed on the advice from generation to generation that one should just take any course that Gene taught, whether or not it was required or in one's specialty. Few could name another faculty member capable of teaching advanced courses in such a wide variety of topics. He was extremely popular with undergraduates as well. He was always approachable, clear and empathetic.

Eugene Commins in his office preparing a lecture.
(Undated family photo.)

Perhaps the most famous of Gene's courses was graduate quantum mechanics. Students would wait to take graduate quantum until a year when Gene was teaching it. Stories circulated about how a professor famous for teaching quantum mechanics in the chemistry department—when Commins was teaching the course in the Physics department—would tell his students "Don't take my course, go over to Physics and take quantum mechanics from Commins. I would if I were you!" For decades the notes from Gene's quantum mechanics class were the bases for courses taught by his former students at Universities around the country. After much prompting he finally, in his retirement, sat down to write his notes into a textbook. The book was published the year before his death.

Gene's philosophy of teaching was simple:

> *While I have been teaching physics for more than 40 years, I don't know anything about formal pedagogical methods, and to me the psychological processes associated with teaching and learning are nearly as mysterious as they were when I was a beginner. The only thing I know for certain about teaching is that I should try to explain concepts in physics to students so that I can understand them, and the most important thing I know about learning physics, at least from my own experience, is that inspiration counts above everything else.*[6]

Gene would admit that he was proud of his classroom teaching record in the department but he was even more proud of his graduate students. He wrote "At Berkeley I have been extremely lucky to work with many excellent research students over four decades…I think I have drawn far more inspiration from them than they ever got from me."[7] He considered working with his students the most satisfying part of his career at Berkeley and he took great pleasure in watching his students develop as scientists and as human beings.

Gene was a phenomenal PhD supervisor. For those of us fortunate to have been his PhD students, we were all in some way branded by him. For many of us, maybe most of us, we chose to work with Gene because of 'who' we were working with, not 'what' we were working on. We wanted to learn to think about physics the way he did and to understand it with the depth he understood it. Gene's students were a privileged few whose training was unsurpassed anywhere. A truly extraordinary fraction of his graduate students went on to become leaders in the physics community. Gene was not only a scholar himself but he had a unique ability to turn students into excellent scholars in their own right.

On the occasion of Gene's second University of California distinguished teaching award in 1979 his close colleague J. D. Jackson wrote:

> *In a field that is difficult and demanding on the graduate level…[Gene]… has been especially effective as a guide, capable of knowing the level of student understanding, and yet able to lead them toward more complex areas of knowledge. He is a teacher who does not limit his student contact to a few hours per week. Professor Commins is to be found in the lab working beside his students, building equipment, taking*

data, helping to make a very difficult experiment work. The atmosphere within his lab is one which encourages students, for the teacher is there participating in all aspects of being an experimentalist, discussing subtle theory, or doing the less dignified tasks of working with the plumbing and machinery.[8]

Eugene Commins (viola) and Erwin Hahn (second violin) playing string quartets with two uniden-tified colleagues. Date unknown. (Photo courtesy of Lawrence Berkeley National Laborartory.)

A genuinely modest man, Gene was a bit embarrassed by the accolades his teaching received, including both the Oersted Medal that recognizes notable contributions to the teaching of physics (2005) and the J. D. Jackson award for excellence in graduate teaching (2010) from the American Association of Physics Teachers. He would often deflect compliments with a comment that others were more deserving or that the conveyer of the compliment was exaggerating. While he was trying to do a good job and was proud of what he had done, he insisted that others in the department consistently did just as well or better and never seemed to be noticed.

Gene taught by example in many ways. Whether in the lab, the classroom, or the machine shop with his students (he never asked his students to do things he didn't do himself) he was enthusiastic about physics and expressed an interest and broad knowledge of many scholarly topics. His former student Nobel laureate Steven Chu wrote: "Eugene had an uncanny ability to bring out the best in all his students. He was a model of what a scientist and mentor should be."[9]

The broader human being

Gene was fairly formal in his interactions, at least initially, and he did dress formally (even in the machine shop) for a Berkeley physics professor. But behind the formality was a wonderful and warm and very human individual. And that very human Gene was as much a mentor and advisor for his students as the physicist was.

> "...if you choose a problem that's really interesting, then chances are it's not solved, and there's always going to be danger in that. But it's really worth it, in the end, isn't it?"

Gene felt that art, music and science went hand in hand. He sketched and painted his entire life and physics notes and scraps of paper in the lab would be filled with imaginative sketches if left out for too long. He painted as an escape, saying that he did not think of anything else while working on a painting. The UC Berkeley Faculty Club exhibited his work several times. He loved music and was an enthusiastic chamber music player, often including students in musical evenings with Erwin Hahn and others. He was extremely broadly read and introduced generations of physics students to Faulkner with the little known novel Intruder in the Dust, a gem of a story that smooths the path to Faulkner's more complex work. In the Commins' lab, reading literature or listening to music was an acceptable activity while an experiment was running. The example of a life well lived, focused on physics but with appreciation of music, literature, and art made a huge impression on all of us around him.

Tragedy struck Gene's life multiple times with the untimely deaths of his younger son, Lars, his first wife Ulla, and a beloved nephew, Bill Bennett. Gene suffered terribly with these losses, and yet never seemed to lose his interest in life or in physics. His older son, David, was a source of great support in dark times, and Gene was tremendously proud of David's two children, Niki and Luke. His second marriage to Iris Ratowsky in 2014 gave him a chance to be happy once again—but it was happiness tragically cut short by his developing illness. The grace, fortitude, and courage with which Gene faced the trials of an inexorable illness made it easier for those around him to deal with it. He was frank in his acceptance of the inevitable but deeply worried about the impact on Iris. His death at the age of 83 leaves his friends and colleagues with a great sense of sorrow and loss.

In 2013 the *Berkeley Science Review* interviewed Gene and asked him what advice he had for current students of physics. His response was characteristic:

> *Well, you have to take the long view, and you need to have self-confidence. But I think the most important thing is courage. When you try to do something interesting, it will certainly be hazardous. There's a high likelihood it won't work. You see, if you choose something that's sure to work, it's not going to be interesting. But if you choose a problem that's really interesting,*

> *then chances are it's not solved, and there's always going to be danger in that. But it's really worth it, in the end, isn't it?*[10]

Gene always took the long view and he fully integrated teaching and research because teaching made the research better and research made the teaching better:

> *Ours is a beautiful science, and one very good way for us to sharpen our knowledge and understanding of it is to teach. I think it is also true that no matter how often one teaches a particular subject in physics, one can always find inspiration by thinking of new and different ways to understand and elucidate subtle phenomena and hard problems.*[11]

We miss him.

NOTES

1. Commins, Eugene D. (2005) Oersted Medal Lecture January 2005: Those Who Inspired Me. *American Journal of Physics* 73:587. Reproduced with the permission of the American Association of Physics Teachers.
2. ibid
3. ibid
4. Eugene Commins, private communication.
5. Unpublished letter from physics department chair Burton Moyer to Chancellor Edward Strong dated February 27, 1963.
6. Commins, Oersted Medal Lecture.
7. ibid
8. Citation read by J. D. Jackson at presentation banquet, Berkeley Faculty Club, May 16, 1979.
9. physics.berkeley.edu/memories-of-professor-eugene-commins. (Accessed November 2016.)
10. Lee, Teresa. (2013) Faculty Profile: Eugene Commins. *Berkeley Science Review*. berkeleysciencereview.com/article/eugene-commins/. (Accessed November 2016.)
11. Commins, Oersted Medal Lecture.

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