BIOGRAPHICAL MEMOIRS

Keith Brueckner

March 19, 1924–September 19, 2014
Elected to the NAS, 1969

A Biographical Memoir by William Bialek

Keith Brueckner was a theoretical physicist of considerable technical power who came of age as the mysteries of the atomic nucleus were coming into focus. His fundamental contributions to the "many-body problem" had a lasting impact on our understanding of how the macroscopic behavior of matter emerges from the underlying microscopic rules. A passionate and accomplished mountain climber, he listed membership in the American Alpine Club below the National Academy of Sciences on his vitae. During decades of complex interactions between the physics community and the United States government, he helped build structures that allowed himself and many others to provide advice on classified matters, but he also actively raised funds to support opposition to the war in Vietnam. At the peak of his career, he left the Ivy League to help found and build a new university in a small village filled with Marines and retirees: La Jolla, California.

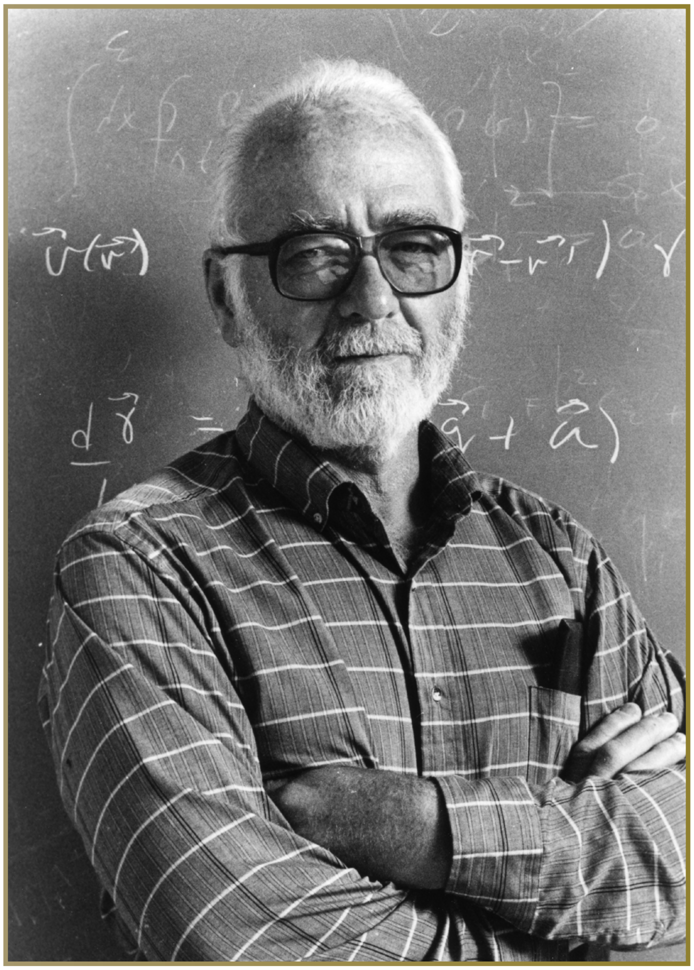

Figure 1 Keith Brueckner, circa 1980. *From the American Institute of Physics Emilio Segrè Visual Archives.*

Introduction

Keith Allen Brueckner was born on March 19, 1924, in Minneapolis, Minnesota. His father, Leo, was a professor of education at the University of Minnesota, an author of mathematics textbooks, and an adviser on educational policy. His mother, Agnes (née Holland), would take a very active role in Keith's university education during World War II. Some combination of nature and nurture produced an intensity and drive in all four of their children. Keith's twin brother, John, was a gifted linguist, wrote a French contextuary for students, and taught high school; his older brother, Richard, became an insurance executive but also worked as an attorney on free speech cases; and his younger sister, Patricia, became a poet.

Keith attended public schools in Minneapolis and entered the University Minnesota in 1941. His first degree was based on a combination of coursework at the university and extension courses during his military service. He was deployed as a weatherman in the Caribbean, where his mother sent him a steady stream of the "great books." While perhaps not the most dramatic thing to be doing during World War II, Keith took pride in his service. Those who only knew the gruff and intimidating senior scientist might have been surprised to hear him break into song:

We are the men, the weather men
We may be wrong, oh now and then
But when you see, those planes on high
Just remember, we're the ones who let them fly

After the war, Keith returned to the University of Minnesota for a year, collecting a master's degree, and then moved to the University of California, Berkeley for his Ph.D. The 184-inch cyclotron had started running at full energy shortly before his arrival, and Berkeley was the center of an exciting interplay between theory and experiment as prewar nuclear physics evolved into postwar particle physics. Keith tried his hand at experiments and then found his calling as a theorist, using very general arguments to understand the recent discovery that bombarding a nucleus with X-rays could produce the elementary particles called mesons. His Ph.D. adviser was Robert Serber and his first theoretical paper was written with Marvin (Murph) Goldberger; Keith and Murph would remain friends for life.

In 1950, with Ph.D. in hand, Keith went east to the Institute for Advanced Study (IAS). Given the long postdoctoral orbits into which our students often are launched today, it seems remarkable that he spent just a year there before becoming an assistant professor of physics at Indiana University. During that year, he overlapped with Freeman Dyson, Murray Gell-Mann, Francis Low, and others with whom his life and career would intersect many times. The summer between the IAS and Indiana was spent at the University of Illinois, where he and Gell-Mann contributed to John von Neumann's classic work on reliable computation with unreliable components.

Keith's first major work at Indiana was about the interpretation of meson-nucleon scattering data, leading to the conclusion that nucleons had an excited state with quantum numbers that could be extracted through analysis of these new experiments. This was near the beginning of the explosion of evidence for "resonances," quickly followed by the discovery of many new strongly interacting particles. Soon Keith's attention would turn from the internal dynamics of single particles to the behaviors that emerge when many particles interact.

Many-Body Theory

In a box with N = 100 particles, there are N^2 = 10,000 ways for them to interact in pairs; if we consider triplets there are N^3 = 1,000,000 possibilities, and so on. Nonetheless, the energy comes out—experimentally—to be proportional simply to the number of particles N. This happens with the molecules in the air around us, and it happens in the droplet of protons and neutrons (nucleons) that comprise a large nucleus, where the interactions among particles are vastly stronger. The surprising fact that the energy and volume of "nuclear matter" are proportional to the number of particles was described in the jargon of the time as the saturation of nuclear forces. If one tried to calculate the properties of nuclear matter using the methods available circa 1950, one found a series of terms with the factors of N^2, N^3, …. Keith liked to say that when he was young, problems were simple: there is a well-defined calculation that should work but gives nonsense.

Keith showed that the series could be organized so that all offensive terms cancel, and the only terms left are proportional to N. Keith described these surviving terms as linked clusters; those that cancelled were unlinked. Jeffrey Goldstone soon showed that this was true to all orders of perturbation theory. Further, one could adapt the diagrams that Richard Feynman had introduced to organize calculations in quantum field theory, and now "linked" and "unlinked" referred literally to the structure of these diagrams.

I once asked Keith what he had missed that left room for Goldstone. He responded that he had "just" checked the patterns out to fourth order, and because it worked, he stopped. He would bring this raw calculational power to bear on problem after problem throughout his career.

Despite the very strong interactions among nucleons, Maria Goeppert Mayer and Hans Jensen had shown that one could understand many properties of nuclei in a "shell model," in which the constituent particles moved as if they were nearly independent. This was even more surprising than the saturation of nuclear forces. In a series of papers, Keith and his colleagues showed that the strong but short-ranged nature of nuclear forces meant that the linked cluster expansion was dominated (in modern terms) by a particular class of "ladder" diagrams and that one could sum an infinite series of these terms. This summation embodied the intuition that when two particles collided, they would interact many times before escaping from one another. As a result, single nucleons move almost independently through a "self-consistent field" created by the other particles. These calculations, in collaboration with John Gammel, would become very complex, taxing the most powerful computers of the time, but they gave semi-quantitative agreement with the extrapolated properties of nuclear matter.

Keith's work on nuclear matter was far from the last word on the subject. It seems to have been difficult, at the time, to disentangle approximations that had physical content from those which were made for numerical convenience. Hans

Bethe played a crucial role in clarifying and reformulating what Keith had done, and the two maintained a vigorous correspondence, sharing their enthusiasm for the details of complex calculations. A large community continues to build on the foundation that Keith laid in the 1950s, and the nuclear many-body problem has renewed relevance to the dynamics of nucleosynthesis, neutron stars, and supernovae.

In contrast to the interactions among protons and neutrons in nuclear matter, the Coulomb interactions between electrons in a metal are relatively weak, but they extend over very long distances. In effect, every electron can "reach" every other electron, and the total interaction energy is in danger of becoming infinite. In the early 1950s, a variety of intuitive approaches were introduced to tame this infinity. Armed with the linked cluster expansion, Keith collaborated with Murray Gell-Mann to show that the divergences were dominated by a class of "ring" diagrams, and they summed an infinite set of these terms to recover finite answers, systematizing the intuitive arguments.[1] As students twenty years later, this still seemed like magic to many of us.

A snapshot of Keith's thinking about these issues can be found in his lectures at one of the first sessions of the famed Les Houches Summer School on Theoretical Physics. His lectures, and those of his colleagues from both sides of the Iron Curtain, captured the excitement of realizing that the electron gas, nuclear matter, superconductivity, and superfluidity really were all part of a single subject. Les Houches, looking across to Mont Blanc, also connected with Keith's interest in mountaineering, and he would return to the region many times.

Keith traveled to Moscow in May 1956 for a conference hosted by the Academy of Sciences of the Soviet Union. He was in a group of thirteen U.S. physicists, and it was a remarkable moment.[2] The Cold War was in full force, the Warsaw Pact had been formed the year before, and Nikita Khrushchev had spoken to a closed session of the Congress of the Communist Party near the end of February 1956, beginning the process of "de-Stalinization"; news of this upheaval would spread slowly, appearing in *The New York Times* only in early June.[3] More importantly for our story, Lev Landau submitted the Russian version of "The Theory of a Fermi Liquid" in March 1956, but it would not appear in English translation until January 1957.

Keith enjoyed telling the story of his meeting with Landau, a legendary figure who gave him quite a hard time. "Why," Landau asked him, "were you trying to calculate properties of the ground state of many-body systems, starting from the microscopic interactions? Wouldn't it be easier and more productive to focus on the lowest energy excitations of the system above the ground state?" To his credit, Keith admitted that he simply didn't understand what Landau was saying—until January 1957, when he could read the Fermi liquid paper.

Keith's work on the many-body problem gave very detailed examples of how relatively simple behaviors could emerge from the daunting complexity of interacting systems. Among his other insights, Landau saw (without detailed calculation) that this simplicity allows powerful predictions to be made about excitations, such as the way heat is conducted through a fluid or electrical current through a metal. These ideas would be clarified dramatically in the next generation and now provide a confident starting point for physicists' approach to ever more complex systems, far from where Keith and his colleagues began.

Although more would come, this early work on the many-body problem was the primary motivation for the honors bestowed on Keith over the years: the call to an endowed chair at the University of Pennsylvania (1956); the Dannie Heineman Prize for Mathematical Physics from the American Physical Society (1963); election to the American Academy of Arts and Sciences (1968) and the National Academy of Sciences (1969); and an honorary doctorate from Indiana University (1976).

University of California, San Diego

> *In the late fall of 1958 I spent a few days in San Diego consulting at General Atomic. Two geophysicists, Leonard Lieberman and Carl Eckart, at the Scripps Institute of Oceanography, knew that I was visiting ... they asked me to have lunch with them the next day. ... When they arrived to pick me up at General Atomic, they had brought along a very tall suntanned man, Roger Revelle.*[4]

Roger Revelle was the director of the Scripps Institute of Oceanography and had been given the task of planning a new campus for the University of California. What today is the University of California, San Diego (UCSD) was then largely vacant land in La Jolla, partially occupied by Camp Matthews, a Marine training base. It was (and is) a spectacular location. It also was the edge of civilization. As Revelle noted in his remarks at Keith's retirement dinner, not everyone could see the great university that would rise in that empty space.[5]

Keith agreed to join the adventure, along with chemists James Arnold and Harold Urey and biologist David Bonner. His immediate responsibility was to build a physics department, but he would influence almost every aspect of academic life on the new campus. In his description, it was an almost magical time of generous and enthusiastic state support for higher education.

Keith moved to La Jolla in the fall of 1959. By 1962, the physics department included theorists Walter Kohn, Norman Kroll, Maria Goeppert Mayer, Marshall Rosenbluth, and Harry Suhl, as well as experimentalists George Feher and Bernd Matthias, all of whom would be elected to the National Academy of Sciences. Also in the first group of recruits were Geoffrey and Margaret Burbidge, who would become Fellows of the Royal Society of London. The Burbidges, still fresh from their pioneering work on the origin of the elements, provided the nucleus for an astrophysics group, and Margaret also would have an extraordinary impact on the status of women in physics and astronomy, both by example and through explicit advocacy. Kohn did his foundational work on density functional theory that was recognized by the 1998 Nobel Prize in Chemistry while he was on the UCSD faculty. Feher would bring his spectroscopic talents to bear on the problems of photosynthesis, launching a whole field of biological physics. Plasma physics and condensed matter were (then) not so well represented at most U.S. universities, and the first cohorts of Ph.D. students at UCSD included many future leaders in these fields. Keith exhibited good taste; with Revelle and the resources of the University of California behind him, he was also very persuasive.

Keith was especially proud of bringing Maria Goeppert Mayer to UCSD in 1960. Mayer would share the 1963 Nobel Prize in Physics for her theoretical work on the nuclear shell model, but her career trajectory meandered through a minefield of misogyny. Indeed, in those years, policies with the stated goal of combating nepotism often were cited by universities as reasons not to appoint the female half of even the most distinguished academic couples. Keith was delighted that the University of California could do the right thing and appoint her a full professor in the Department of Physics, with no asterisks on account of her gender or marital status; coincidentally the Department of Chemistry was able to add a distinguished theorist to its ranks in the person of Maria's husband, Joseph Mayer. To capture the environment in which these decisions were being made, it is worth recalling the local newspaper headline: "San Diego Mother Wins Nobel Physics Prize."

In addition to being the founding chair of the Department of Physics, Keith recruited leaders for the Department of Mathematics and the engineering school. He helped bring some of the first literary scholars and linguists to the campus, as well as George and Jean Mandler, who formed the nucleus of a very forward-looking Department of Psychology. As he so often did in those early days, Keith flew out to see the Mandlers in Toronto; George recalled "... [a] day spent sitting on the floor in our living room, hearing about the promise of UCSD. ... [B]y the time Keith left I was sold."[6] In philosophy, he recruited the prolific Avrum Stroll, who would become a dear friend and who in turn recruited Herbert Marcuse.

In those early years, Keith served on the Director's Administrative Advisory Council, on committees to oversee the expansion of the humanities and social sciences, the construction of almost every building, planning for undergraduate education, the establishment of residential colleges, and recruitment of faculty in the fine arts. He chaired committees to review the campus master plan and to look ahead to a second decade. He brought the first computer and recruited the first librarian. All of this in just the few years from 1959 to 1965.

Keith's success in recruiting became the stuff of legend. He enjoyed recounting the process, describing his constant travel and discussions, and recalling how he used each positive indication from one candidate as part of the sales job for the next. The first recruits were united by a spirit of adventure that stayed with them for decades, and many saw Keith as the most adventurous of all.

The real history is messier than the legends. The whole process of creating UCSD began very informally. Faculty were being recruited to a university that did not quite exist, with no departments or department chairs. Walter Kohn insisted that he would come only if Keith were appointed as chair of the physics department once things solidified. As the structures began to form, Keith was hugely disappointed that Roger Revelle was not asked to serve as the new campus's first chancellor. This disappointment certainly played a role in his decision to take a leave of absence from UCSD, serving as vice-president of the Institute for Defense Analyses (see below). When Keith returned to campus, he was appointed dean, but correspondence from that time reveals surprising ambiguity about his actual responsibilities.

By the mid-1960s, conflicts with the upper administration became more frequent and Keith moved away from his multiple responsibilities. One late contribution was a vision for continued growth of the Physics Department he had founded. He argued that the department needed to grow by roughly a factor of two from 1965 to 1972, and that this growth needed to be balanced across many different fields of physics in order to meet the emerging intellectual challenges. Particularly noteworthy was his proposal for the growth of biophysics as a branch of physics, and the idea that this should be supported in part with resources drawn from the medical school. This suggestion was in clear opposition to some of his prominent biologist colleagues, who saw biophysics as a branch of biology and argued against any physics-centered efforts. Keith's argument won out, and UCSD became the first major U.S. physics department to have a significant presence in the field, which continues today.

By any measure, the project of building UCSD was a great success. Keith Brueckner and Roger Revelle probably contributed more to this success than any other individuals.

Nonetheless, in private discussions I sometimes sensed that Keith was a little disappointed. What he and his colleagues had built became a great university, but one rather like all the other great universities of its time. He, and they, had hoped for something different. He foresaw the problems of teaching in large lecture halls rather than in intimate discussions at the blackboard and stayed long enough the see the start of declining state support for public universities, as well as political meddling in university governance. But his enthusiasm for physics, for science more generally, and for the special intellectual life of the university persisted until the end.

ADVICE AND DISSENT

As with many theoretical physicists of his generation, Keith spent time at what is now the Los Alamos National Laboratory consulting on the nuclear weapons program and taking advantage of the computing facilities to push forward his basic scientific work. In the late 1950s, a handful of those colleagues began to think that additional structure was needed in order to provide the government with the best possible scientific advice. A first step in this direction was Project 137, a summer study group led by John Wheeler that included Keith, Murph Goldberger, and Kenneth Watson, among others. These three would take the lead in a more ambitious effort that was organized under the auspices of the Institute for Defense Analyses (IDA). Together with Murray Gell-Mann and Charles Townes (then vice-president of IDA), they formed the steering committee for a consulting group called JASON, named for the mythological leader of the Argonauts at the suggestion of Mildred Goldberger.

The initial JASON group included Subrahamanyan Chandrasekhar, Freeman Dyson, Val Fitch, Donald Glaser, Norman Kroll, Leon Lederman, Francis Low, Walter Munk, Malvin Ruderman, Edward Salpeter, and Sam Treiman. There was also an effort to engage promising younger people, including Henry Kendall and Steven Weinberg. An important part of the plan was that the group would not be asked specific questions by government agencies, but rather be presented with a variety of issues and concerns out of which they would formulate questions for deeper investigation. This independence, part of the original vision articulated by Keith and his colleagues, would eventually become a source of friction between JASON and its government sponsors.

In 1961, Keith took a leave from UCSD to serve as vice-president of the Institute for Defense Analyses, taking over from Townes. For a little over a year, he helped build the IDA technical staff with much the same energy that he had brought to recruiting at UCSD. But as Keith himself described it, "In my enthusiasm and inexperience with the Washington scene, I had some conflict with the governing board of IDA. …" He was also disappointed by the appointment of Richard Bissell as president of IDA; Bissell had been deputy director of the Central Intelligence Agency, where he led the planning for the Bay of Pigs invasion. Keith returned to UCSD in 1963 and stepped away from JASON. He continued to consult but never again took a leadership position.[7]

While still at IDA, Keith took time to lecture at Georgetown University. He emphasized that massive support for military research was having a detrimental effect on science more broadly, pulling people away from fundamental problems. More subtly, he argued that the scale of funding was distorting the marketplace and effectively reducing the attractiveness of teaching in high schools and small colleges. These observations seem quite prescient. He also railed against the image of scientists as geniuses and the mistaken impression that science is too difficult.[8]

After Keith's departure from the group, JASON was subject to increasing criticism for its involvement with the Vietnam War. By May 1970, in the wake of escalation into Cambodia, UCSD buildings (as on many campuses) were occupied, and Keith was targeted by students aware of his continued engagement with the defense establishment. He responded in the campus newspaper, stating his positions on the issues of the day: (1) The United States should withdraw immediately from Southeast Asia; (2) the federal government should transfer research funds from the defense agencies to the National Science Foundation; (3) the University of California should terminate management of the nuclear weapons laboratories; and (4) the rapid growth of science at UCSD led to "unbalanced structure, detrimentally affecting the over-all quality ... [and] retarding the growth in humanities, social sciences, and fine arts." The next year, Keith and his wife Elsa hosted an anti-war fundraising event featuring the recently paroled activist David Harris, along with actors Jane Fonda and Donald Sutherland.

Keith believed strongly that policymakers, in particular those working on defense and national security, needed the best possible scientific advice. He held to this position despite his strong opposition to the policies that were being made. Although his version was especially stark, many physicists of his generation found themselves similarly caught between advice and dissent.

CONTROLLED FUSION

> *[S]ummer of 1955. Ken Watson recruited Keith Brueckner, Geoff Chew, Francis [Low], and me to work on what was then the classified program on controlled fusion. This was a rather bizarre experience. ... somehow Keith had become an expert on plasma physics. Geoff, Francis, and I didn't know beans....*[9]

Keith's old friend Murph Goldberger reminds us here that the search for fusion power, which today is the subject of frequent news articles, started as a secret project. The dream was to harness the energy source that powers the Sun for use here on Earth.

The initial and still dominant idea was to use magnetic fields to confine a plasma that could then reach the extreme temperatures and densities needed for fusion to occur at high rates. The invention and rapid development of optical lasers in the early 1960s led many people to wonder if a powerful pulse of laser light could be used to send controlled shock waves through a material target. In his role at the Institute for Defense Analyses, Keith organized a summer study on high-powered lasers in 1963, and this was one of the first places where the possibility of laser fusion was discussed.

It was clear that progress would require a combination of theory, simulation, and rather large-scale experiments. In particular, a wide variety of unstable flows can disrupt the extreme conditions that are the goals in both magnetic confinement and laser-driven fusion. Keith was fascinated by the challenging theoretical problems, and he was no stranger to large computations. He and his colleagues seem to have been near the origin of the idea to use multiple lasers as the hydrodynamic driver for direct implosion of a spherically symmetric composite target. This work in 1969–70 was classified by the Atomic Energy Commission (AEC) and would be declassified over a period of several years, culminating in the publication of a major technical review article written with Siebe Jorna in 1974. Even in 1975, Keith could not tell how much of his path through the subject had been charted independently by colleagues at the AEC laboratories.

Much of Keith's foundational work on direct-drive laser fusion was done while on leave from UCSD to KMS Fusion, a private company. Based on this theoretical work, and after much negotiation, KMS obtained a no-cost contract in 1971 from the AEC. Keith became the technical director of the company and (once again) recruited a substantial staff. By 1974, there was a working experimental system that was performing diagnostics to test the theory and achieving neutron—producing implosions as multiple laser pulses converged symmetrically on spherical targets with glass shells. Keith stepped away from KMS shortly after, and experimental work continued under the direction of Robert Hofstadter.

Keith continued to work on physics relevant to laser fusion after returning to UCSD. At the start, he had to produce written versions of his seminars, knowing an FBI agent would be following along to be sure he didn't deviate from the script. He was commissioned by the Electric Power Research Institute to assess the prospects for laser fusion and assembled a team of colleagues. Their impactful report, published in 1977, included fascinating windows into previously classified data.

Keith returned to Les Houches to lecture on laser-plasma interactions at the 1980 Summer School, sharing his excitement with a new generation.[10] He took a special interest in the progress of fusion research in the Soviet Union and corresponded with Nikolay Basov on the subject. They had hoped to meet at a conference in La Jolla in 1980, but U.S. visas for Soviet scientists were revoked in response to the internal exile of Andrei Sakharov. Closing the circle, Nikolay's son, Dmitri Basov, would join the UCSD physics department a few years after Keith's retirement and was chair at the time of Keith's death.

Mountains and Family

Keith had a lifelong passion for climbing. He made regular visits to the Alps, engaging in very technical climbs, often with guides. With time, he also came to enjoy the good food and wine available nearby and would amass a serious cellar of his own. He was a member of the American Alpine Club, and in some versions of his curriculum vitae this appears just below his membership in the National Academy of Sciences. When traveling without his family, he would recount his adventures in letters and postcards, sometimes in more detail than necessary. As with his accounts of different adventures in physics, Keith could tell a story without needing to be the hero, and there is nothing heroic about waiting out two days of rain while trapped in a tent with your guide.

Closer to home, Keith climbed regularly at the boulders in Joshua Tree National Park and at Mount Woodson. He often introduced young colleagues and students to technical climbing, and with time he enjoyed a reputation as the old man of the mountain. He literally wrote the book on his favorite climbs at Mount Woodson (Figure 2), and copies of this pamphlet circulated widely in the Southern California climbing community. A fuller account of his climbing career, capturing the charm of his letters, was published posthumously.

As he neared completion of his postwar master's degree in Minnesota, Keith married Marjorie Dumas, and they moved together to Berkeley. Their two sons, Jan and Anthony (Tony), went on to distinguished academic careers of their own: Jan as an economist and Tony as a philosopher. Marjorie was Keith's partner through the years at Indiana University and the University of Pennsylvania, when he did his most significant physics. They separated shortly after their move to La Jolla, and eventually Marjorie returned to work as an artist. Fittingly, one of her paintings adorns the cover of Tony's last book.

When Keith married Elsa Dekking, she had four young daughters—Charlotte, Barbara, Jessica, and Carolyn—and

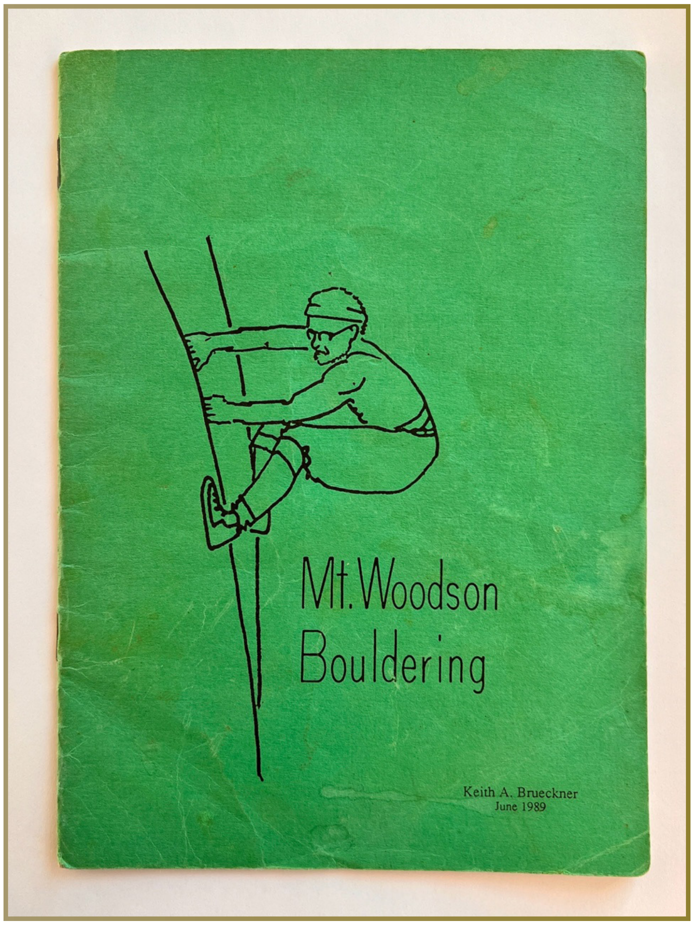

Figure 2 This guide circulated widely in the Southern California climbing community. *Photo by CD Bialek.*

they would have a fifth, Leslie, together; the five girls grew up with "Keithie" as their dad. Born in the Netherlands and arriving in La Jolla via Venezuela, Elsa was Keith's partner in the human side of the recruiting effort that built UCSD. Their older daughters went on to diverse professional lives in the arts, education, agriculture, animal science, and graphic design; their youngest became a public interest lawyer who argued before the U.S. Supreme Court. Keith and Elsa separated in 1981.

Bonnie Lichtenstein married Keith in 1988. She worked as a security administrator at Physical Dynamics, Lockheed, United Technology, and finally the Institute for Defense Analyses and so had strong connections to an important chapter of Keith's earlier life. They lived in La Jolla, enjoyed frequent travels, and were close to Bonnie's children Deborah and Patrick. In his final years, Keith suffered with aggressive dementia, and Bonnie shouldered this burden with courage and grace. He died on September 19, 2014.

Finally, in appreciation (and in full disclosure), I should add that Keith was my father-in-law. I have a vivid memory of my first encounter with him, when Charlotte and I went to visit just a few months after we had met. The physics questions began as he was driving us to dinner and continued through the meal. It was like revisiting my qualifying exam, but with higher stakes. It seems I passed, and talking physics with Keith became a continuing pleasure. He also provided a more personal connection to the generation of my mentors. Keith was not an easy personality, and on learning that I was his son-in-law my senior colleagues often replied with amusing stories.

Keith spent his final years in a memory care facility, a place he described as "an elegant jail." In the garden, on a beautiful afternoon, we reminisced, but soon the conversation became serious. We spoke, for one last time, about what was new and exciting in physics.

Acknowledgments

I am grateful for input from the family: Charlotte Bialek, Jan Brueckner, Leslie Brueckner, and Carolyn Miller; and from the late George Mandler. My sincere thanks also to Colleen Garcia and her colleagues at the UCSD Archives; to Alexandra Briseno at the NASEM Archives; and to Gordon Baym, Jill Dahlburg, and David Zierler for their comments on earlier drafts.

References

1 Keith eventually returned to this problem with his young colleague Shang-Keng Ma, studying the energy of the electron gas with spatially varying density.

2 The attendees were L. W. Alvarez, K. Brueckner, O. Chamberlin, M. Gell-Mann, R. Marshak, J. Marshall, A. Pais, W. Panofsky, E. Segrè, L. W. Smith, J. Steinberger, V. Weisskopf, and R. Wilson. See *Sixth Annual Report of the National Science Foundation*, 1956. Washington, D.C.: U.S. Government Printing Office.

3 Alvarez, L. W. 1957. Further excerpts from a Russian diary. *Phys. Today* 10:22–32. He notes that during the conference, Stalin was still in the mausoleum next to Lenin, but in crucial rooms his portrait had been replaced.

4 This and other quotes are drawn from *Keith A. Brueckner Papers, 1949-1994 MSS 94*, Special Collections & Archives, UC San Diego.

5 Additionally, there were more concrete problems, because much of La Jolla's residential real estate was then governed by restrictive covenants that prevented sales to Jews and others. These would not be fully removed until 1968, with passage of the Fair Housing Act.

6 Mandler, G. 2013. *Interesting Times. An Encounter with the 20th Century*, 1924–, p. 182. New York: Psychology Press.

7 In 1983 I had been offered the opportunity to spend time at one of the weapons labs. Keith's advice was simple: if you can possibly do without the money, don't go. "You have nothing more valuable," he said, "than the time to think about the problems you find important."

8 Breasted, D. 1962. Physicist says students are too wary of science. *Evening Star*, February 15, p. C-14.

9 Goldberger, M. L. 1983. Francis E. Low — A sixtieth birthday tribute. In: *Asymptotic Realms of Physics. Essays in Honor of Francis E. Low*, eds. A. H. Guth, K. Huang, and R. L. Jaffe, pp xi-xv. Cambridge, Mass.: MIT Press.

REFERENCES (CONT.)

10 He would come back to Les Houches once more, just for a visit, in 2001. It was a pleasure to hear him reminiscing, both about physics and about the evolution from the spartan facilities of 1958 to the comfort of the modern accommodations.

SELECTED BIBLIOGRAPHY

1949 With M. L. Goldberger. The excess of negative over positive mesons produced by high energy photons. *Phys. Rev.* 76:1725.

1950 The production of mesons by photons. *Phys. Rev.* 79:641–650.

1952 Meson-nucleon scattering and nucleon isobars. *Phys. Rev.* 86:106–109.

1955 With C. A. Levinson. Approximate reduction of the many-body problem for strongly interacting particles to a problem of self-consistent fields. *Phys. Rev.* 97:1344–1352.

Two-body forces and nuclear saturation. III. Details of the structure of the nucleus. *Phys. Rev.* 97:1353–1366.

Many-body problem for strongly interacting particles. II. Linked cluster expansion. *Phys. Rev.* 100:36–45.

1956 With W. Wada. Nuclear saturation and two-body forces: Self-consistent solutions and the effects of the exclusion principle. *Phys. Rev.* 103:1008–1016.

1957 With M. Gell-Mann. Correlation energy of an electron gas at high density. *Phys. Rev.* 106:364–368.

1958 With J. L. Gammel. Properties of nuclear matter. *Phys. Rev.* 109:1023–1039.

1959 Theory of nuclear structure, and Further applications of the theory of many-body systems. In: *The Many Body Problem (le Problème à N Corps): Cours Donnés à l'École d'Été Physique Théorique, Les Houches, Session 1958*, eds. C. DeWitt and P. Nozieres, pp. 47–241. New York: John Wiley and Sons.

1968 With S.-K. Ma. Correlation energy of an electron gas with a slowly varying high density. *Phys. Rev.* 165:18–31.

1974 With S. Jorna. Laser-driven fusion. *Rev. Mod. Phys*. 46:325–367.

1977 With R. W. Gross et al. An assessment of laser-driven fusion. *Int. J. Fusion Energy* 1:25–54.

1982 Principles of laser confinement fusion. In: *Laser-Plasma Interaction. Proceedings of the 34th Summer School on Theoretical Physics, Les Houches*, eds. R. Balian and J. C. Adam, pp. 539–644. Amsterdam: North-Holland.

1989 *Mt. Woodson Bouldering.* La Jolla, Calif.: n.p.

2016 *Mountaineering: A Personal History*. Bloomington, Ind.: Archway Publishing.