Richard Brewer

1928–2012

BIOGRAPHICAL *Memoirs*

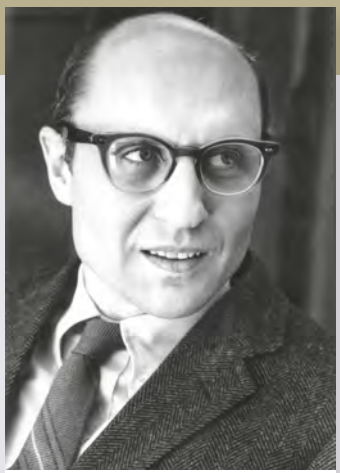
A Biographical Memoir by
Paul Berman
and Erwin Hahn

NATIONAL ACADEMY OF SCIENCES

RICHARD GEORGE **BREWER**

December 8, 1928–July 22, 2012

Elected to the NAS, 1980



By Paul Berman and Erwin Hahn

Richard (Dick) Brewer helped revolutionize the field of modern spectroscopy. He was perhaps best known for his contributions to coherent transient spectroscopy, but Dick's interests embraced a much larger family of experimental and theoretical physics involving atom-field interactions. Colleagues generally agree that one of his most groundbreaking ideas was to produce coherent transients by Stark switching molecular transitions into resonance with a laser field. Considered equally important was his work on the breakdown of the optical Bloch equations in intense laser fields.

A fascinating memoir that Dick wrote in 2003 is available at the website of the American Institute of Physics' (AIP's) Center for History of Physics1. In this memoir, he described his career path, his travels, his collaborations with colleagues, and his personal history. It is clear that Dick was driven to succeed and wanted his work to be recognized by the international physics community. Equally clear is the importance he attached to family values and the friendships he developed over the years.

Richard Brewer was born in Los Angeles as Richard George Alfred Breuer to parents Otto Breuer and Elise Sachs. Both were of Polish origin but had emigrated from Geneva, Switzerland, where Dick's father was a banker. The spelling of the family name evolved to "Brewer" and Dick ultimately dropped "Alfred" from his name. He attended Hollywood High School, where he was on the varsity basketball team. By this time, he had already demonstrated special abilities in physics, chemistry, and mathematics. His interest in science was influenced somewhat by his brother Al, who was 11 years his senior and a student at Caltech when Dick was in elementary school.

From an early age Dick demonstrated a spirit of adventure and risk-taking. When he was 15 years old, he set off on his own to climb Mount Whitney. This love of climbing

and hiking was to endure throughout his life. He worked two summers at the Glacier Point Hotel in Yosemite National Park, where he also found time to learn folk dancing from Jim Taylor, a Native American. To take these dance classes, Dick hiked the Ledge Trail down into the valley from Glacier Point. Although this was a violation of the restriction that the trail be used for ascents only, it did allow him to reach the valley floor in 20 minutes. During these summers, Dick was already a student at Caltech, where he obtained his bachelor of science degree in 1951. He was so enamored with folk dancing that he taught it to some classmates at Caltech and then took them to community folk dances; one such classmate met his wife at one of these dances and was forever grateful to Dick.

A family portrait taken in 1954 showing Dick, Lillian, Larry, Emily, and Cathy. Note the bust of Beethoven in the background.
(Photo credit Lillian Brewer.)

After Caltech, Dick worked at the Aerojet General Corp. for two years, using his background in chemistry to study the mechanical properties of polymers. During this period he took up the cello and continued his folk dancing, concentrating on Yugoslavian and Greek dances. Dick loved classical music and bought a plaster bust of Beethoven that he dragged along each time he changed lodgings—the bust now resides in his Palo Alto home. Dick's interest in classical music can be traced to his childhood, during which it was regularly played in his parents' home. Dick was to maintain his passion for classical music (especially the cello works of Bach) throughout his life. Music played a central role in the adult Dick's family as well. His wife Lillian is an accomplished pianist and piano teacher and his children—Laurence (born in 1955), Emily (born in 1957), and Cathy (born in 1960)—all possess artistic and musical abilities. In later years, Dick was a fan of conductors Georg Solti and Riccardo Muti, attending their concerts whenever they performed in San Francisco.

Dick decided to apply to the University of California, Berkeley, for graduate studies in chemistry in 1953, but he was admitted only into the master's program initially, with no financial support. Within a year, he was accepted into the Ph.D. program and found a research advisor, Leo Brewer (no relation). In 1954 he met Lillian Magidow and they were soon married. Dick's graduate studies were interrupted for two years by military service, but he returned to Berkeley and obtained his Ph.D. in chemistry in 1958.

The first paper he published in 1959 was actually on a theoretical calculation he had made with Edward Teller (although Dick was the sole author). As a graduate student, Dick was attending Teller's lectures and often asked questions. When Dick posed a question on hydrogen to Teller, he responded with, "I have a much better problem on hydrogen for you to work on." Teller suggested that Dick calculate the probability of a nuclear reaction in a hydrogen molecule whose molecular potential barrier was reduced from the pure Coulomb barrier in proton-proton scattering. This calculation ultimately formed part of Dick's doctoral thesis. The other part, involving research with Leo Brewer, was related to the measurement of molecular state lifetimes; it seems that the only publication (aside from the thesis) related to this effort appeared in 1962 in the *Review of Scientific Instruments*.

Upon graduation in 1958, Dick turned down an offer from Bell Labs to accept an instructor position at Harvard University, where he worked on optical pumping and radio frequency transients—subjects that were to serve him well in his career. But in 1960 when he was offered an assistant professorship at the University of California, Los Angeles (UCLA), he was happy to return to the West Coast with his family (now including daughter Emily and son Larry). However, things did not quite go as planned at UCLA, where Dick's work on optical pumping was not especially appreciated. He found out that he was not going to be rehired. Yet this negative event might have been a blessing in disguise; he was offered a staff position at IBM Research Laboratories in San José, which he assumed in 1963. And when a new IBM research facility opened in Almaden in 1986, Dick moved there.

In his early work at IBM, Dick used a ruby laser to demonstrate stimulated Brillouin scattering in liquids. He had read about research using quartz as the scattering medium and was convinced that a similar effect should occur in liquids. After observing that effect and submitting a paper to *Physical Review Letters*, he "was so excited that he had trouble sleeping that night."[2] The paper was rejected at first, but subsequently accepted. Dick was

invited to a Gordon Conference in 1964 to report on this work, where he met Charles Townes, Boris Stoicheff, and Joe Giordmane.

Shoemaker also recalled that the laboratory was a model of design and cleanliness. Such attention to detail was also evident in the careful wording and editing of all of Dick's publications.

As a result of these contacts, Dick was invited to spend part of the summer of 1966 working in Townes's group at MIT. The researchers' work on laser field trapping and filamentation in condensed matter systems, carried out during that short three-week visit, resulted in three papers. Elsa Garmire was a postdoctoral student in the group at the time. As they became friends, she recalls that her and Dick's paths had crossed previously when she was a student at Radcliffe College and Dick was the head teaching assistant of a course she was taking at Harvard. Dick had helped her to overcome some difficulties she was having in the course.[3]

Dick also met Ali Javan during those three weeks at MIT, and Javan invited Dick to return to MIT as a visiting professor for the 1968–69 academic year. This year was to prove critical in Dick's career, as it was then that he entered the field of nonlinear infrared spectroscopy. Dick had the idea to use Lamb-dip spectroscopy outside of the laser cavity. He observed molecular transitions in naturally abundant $N^{14}H_2D$ molecules using a standing-wave CO_2 laser field to drive the transitions and a Stark electric field to tune the transitions into resonance with the laser field. By sweeping the Stark field instead of the laser field frequency through resonance, he discovered that an extremely narrow Lamb dip occurs in absorption, providing a sensitive method for high-resolution laser spectroscopy of gases. Dick received a complimentary letter from Nobel laureate Willis Lamb on this work, and it is safe to say he was very pleased by this recognition.

On returning to IBM, Dick now realized that he could simulate a pulsed optical field interacting with a molecular electric dipole by using a continuous wave optical field and Stark switching the molecular transition frequency into and out of resonance with the optical field. Dick believed that by using this technique he could see a photon echo and explore other optical coherent transient effects as well. As stated by Richard Shoemaker, who was a postdoctoral student working with Dick at that time: "It was one of those rare events where an experiment not only worked the first time it was put together, but also worked far better than expected. I don't think it was until a little while later we realized that the primary reason the experiment worked so well is that we

Dick, Erwin Hahn, and Boris Stoicheff in Hakone, Japan, 1977.
(Photo credit Lillian Brewer.)

had a built-in heterodyne detection system."[4] The heterodyne signal was produced by classes of molecules that were switched both into and out of resonance by the Stark fields, also producing coherent optical free induction decay and Rabi nutation. These results had a profound effect on the field of optical coherent transients.

Shoemaker also recalled that the laboratory was a model of design and cleanliness. Such attention to detail was also evident in the careful wording and editing of all of Dick's publications.

One of us (PRB) received a call from Dick in the fall of 1972. Dick had called Willis Lamb, whom he had met on several other occasions, with a question regarding the role of collisions on photon echo decay signals, given that Lamb and Berman had recently published several papers on collision-induced modifications of spectral line shapes. Dick would have probably preferred to collaborate with Lamb, but Lamb referred him to Berman, who had just become an assistant professor at New York University. Dick had observed that collisions in methane vapor resulted in a decay of a photon echo signal that differed qualitatively from that produced by frequency perturbations in solids. The next step was that Brewer and Berman, together with Jan Schmidt and Joel Levy, carried out a theoretical and experimental study of the role played by velocity-changing collisions in diminishing the photon echo signal. Dick subsequently invited Berman to attend the first International Laser Spectroscopy Conference in Vail in 1973, where results of the work were reported. But the story didn't end there. The initial phone call to Berman was the start of a friendship and professional collaboration between Brewer and Berman that continued until Dick's death.

As was evidenced by his work with Edward Teller, Dick was ready to carry out theoretical as well as experimental research, and he had the opportunity to invite young scientists to visit his group at IBM. In 1974, Stig Stenholm was at IBM on such a visit and began working with Dick on a systematic analysis of coherent transients in two- and three-level

atoms. They were joined in this research by Erwin Hahn, who was an expert on coherent transients in the radio-frequency domain.

Stig helped Dick to understand the origin of some spectral features that Dick and Shoemaker had observed in their laser spectroscopy of three-level atoms. These structures were found to result from collision-induced crossover resonances. Stig recalls meeting on Sundays at a local pool where they tried to unravel the mysteries of the resonances and then wrote the text of the paper sentence by sentence while still in the pool[5].
The research into three-level systems continued as Dick developed a method to study coherent transient Raman beats after first preparing a coherent superposition of states among degenerate sublevels in a molecule—and then suddenly lifting the degeneracy by Stark switching. A related theoretical paper coauthored with Erwin Hahn on coherent two-photon processes became Dick's most cited research paper. In that paper, the Bloch equations were solved for a three-level atom interacting with two continuous wave or pulsed laser fields.

Dick realized that he could extend the observation of coherent optical transient effects to molecules without a permanent dipole moment; to do so would require switching the laser frequency instead of the molecular transition frequency, as had been done with the Stark effect. He and Azriel Genack developed a general technique for observing optical coherent transients using laser frequency switching and heterodyne detection. The laser frequency was switched by applying voltage pulses to an intra-cavity electro-optic crystal. The method could be used quite generally to observe coherent transients on optical transitions in atoms, molecules, and solids. Moreover, the techniques that Brewer and Genack developed enabled them to separate various contributions to relaxation processes that degraded the signals.

Dick and his IBM colleague Ralph DeVoe worked together on a number of important projects. Together with Alex Szabo and Stephan Rand, they carried out one of the first experiments in which ultralong lifetimes of optical coherence were observed in solids doped with rare earth ions. The rare earth ion work led to the discovery of the breakdown of the optical Bloch equations at high field intensities: the intense fields reduce the dephasing attributed to relaxation processes in which the transition frequency of the ions undergoes stochastic jumps. DeVoe recalls that Dick was in the room when the first data indicating a violation of the optical Bloch equations were obtained[6]. One of us (PRB) then worked with Dick on the theory of the process.

Dick also collaborated with Axel Schenzle, who was a visitor at IBM. At the time there was some controversy as to whether or not quantum jumps could be observed on a single ion. Axel and Dick showed that such effects were to be expected. Axel recalls that "Dick liked to tell how as a young student he worked one summer as a junior park ranger in Yosemite. The park in those days was not that overcrowded, so he spent long lonely days at the Merced River or climbing up to Half Dome. At the end of his stay he was so overwhelmed by this intimate contact with nature that he could not imagine returning to the city again."[7]

Together with DeVoe and others, Dick's last major experimental effort was devoted to a study of individual atomic ions in planar microcavity traps. This work culminated in the demonstration of sub- or superradiance in the spontaneous emission of two ions, depending on their separation. By using nanofabrication techniques, the researchers were able to position ions having separation distances on the order of a transition wavelength and observe an oscillation of the decay rate as a function of this separation. This was the first time that the collective decay rate of a two-atom system was measured directly as a function of the separation of the atoms. It remains one of the only experiments of its kind.

At IBM, Dick had the support of Ken Foster, a highly regarded technician who Dick met shortly after arriving. Ken had come to Dick's aid when Dick was trying to align the mirrors of a He-Ne laser. About a year later, Ken accepted an invitation to work in Dick's group and remained there for 25 years, providing important technical support for the team's research efforts. Dick recalled that Ken was not only friendly and a team player, but also inventive. An example of Ken's creativity was to construct an optical table using a granite slab purchased from a tombstone maker that was then mounted on a wooden frame and "floated" on 20 inflated motor-scooter inner tubes.[8]

Dick was the recipient of many awards and other honors. He was elected an IBM Fellow in 1973 and a member of the National Academy of Sciences in 1980. He received the Albert A. Michelson Gold Medal of the Franklin Institute in 1979, the California Institute of Technology Distinguished Alumni Award in 1994, and the Charles Hard Townes Silver Medal of the Optical Society in 2000. In 1992 a symposium in honor of Dick, organized with support from Stanford University and IBM, was held at Stanford University. In 1997 he endowed the Brewer Prize at Caltech, which is awarded annually to a freshman who is deemed the best at overcoming two "hurdles" that are prerequisite to admission into a research tutorial in which the student carries out an independent

research project. With Aram Mooradian, Dick organized the first International Laser Spectroscopy Conference, an event that continues to be held in worldwide venues.

Dick's induction into the National Academy of Sciences in 1981. Pictured with him is home secretary Bryce Crawford Jr. (Photo credit Lillian Brewer.)

Dick's eminent scientific status resulted in invitations to conferences and institutions all over the globe, and he took full advantage of these occasions to experience the cultures of many different countries. For example, Dick and Lillian toured London, Paris, and Moscow on their way to a conference in Yerevan, Armenia, in 1967. He was a regular attendee, of course, at the International Laser Spectroscopy Conferences, which are typically held in mountain (often ski) resorts in June. Dick visited Japan on several occasions; he was a visiting professor at the University of Tokyo and gave lectures at several different universities across the country. In fact, Dick's collaborations in Japan helped lead to a U.S.–Japan Cooperative Science Program. He also had a special fondness for Italy and the Italian culture, to the point of learning to read and speak Italian.

Dick, Aram Mooradian, and Jan Hall in Shanghai, 1980. (Photo credit Lillian Brewer.)

Throughout most of his career, Dick had an unusual tenacity in carrying out what he wanted to get done and in doing what he enjoyed, no matter the roadblocks. But his work was finally cut short by the progression of a debilitating neurological disease that was first diagnosed in the early 1980s. For someone who loved to travel, hike, and explore the outdoors, this disease might have been viewed as a telling blow. Fortunately, Dick's quick mind, curiosity, love of learning, interest in people, and sense of humor were immune from the attack on his body. He continued to study, keep up with developments in physics, improve his Italian, and offer reminiscences about many of his colleagues, virtually to the end of his life.

Dick died of cancer on July 22, 2012 and is survived by his wife Lillian, whom he met at Berkeley in 1954. Although the courtship lasted only three months, the marriage endured for another 57 years. He is also survived by his son Laurence and his daughters Emily and Cathy. It was the love of his family that helped sustain him during the difficult years of his disease. The importance of Dick's own love of family is evident in the wonderful Memoir that is available at the AIP's Center for the History of Physics website.[1] The family hiking and travel adventures, as well as the accomplishments of his children, are described in a manner that clearly evokes an image of a caring and proud parent.

We thank Lillian Brewer, Ralph DeVoe, Elsa Garmire, Azriel Genack, Axel Schenzle, Richard Shoemaker, and Stig Stenholm for their input in composing this memoir.

A family portrait taken in 1993 on the occasion of Dick's 65th birthday. (Photo credit Lillian Brewer.)

NOTES

1. Brewer, R. G. 2003. Memoirs. Available from the Center for History of Physics at http://www.aip.org/history/catalog/icos/25849.html.
2. Memoirs, 53.
3. Garmire, E. 2013. Email communication.
4. Shoemaker, R. 2012. Email communication.
5. Stenholm, S. 2013. Email communication.
6. Devoe, R. 2012. Email communication.
7. Schenzle, A. 2013. Email communication. There does not seem to be any evidence that Dick was actually a "junior park ranger."
8. Memoirs, 170–171.

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