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HARRY GEORGE DRICKAMER
1918–2002

A Biographical Memoir by

JIRI JONAS

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HARRY GEORGE DRICKAMER

November 19, 1918–May 6, 2002

BY JIRI JONAS

HARRY GEORGE DRICKAMER ("Doc" to all his students) was a pioneer in high-pressure studies of condensed matter, with a major focus on pressure tuning spectroscopy. The energies associated with different types of orbitals can be varied to different degrees by compression. From these perturbations a wealth of information can be obtained about the electronic and vibrational properties and molecular interactions in various systems. The concept of pressure tuning, which Harry Drickamer developed and exploited, became a tool of great power and versatility, presently used by many research groups throughout the world. Harry Drickamer's own research has had a strong impact in the fields of physical, inorganic and organic chemistry, chemical engineering, solid-state physics, geophysics, and biochemistry. From an experimentalist's point of view it is most remarkable that Harry Drickamer was able to develop and perfect high-pressure instrumentation for so many spectroscopic and nonspectroscopic techniques, to name a few: infrared spectroscopy, Mossbauer spectroscopy, fluorescence spectroscopy, X-ray diffraction, conductivity measurements, and scintillation experiments. Furthermore, he was the first to develop instrumentation for high-pressure experiments to many hundreds of kilobars.

Thanks to the research accomplishments of Harry Drickamer, pressure is widely recognized as a versatile and essential tool in condensed phase science: There are now hundreds of papers involving high-pressure studies, many of them extending, amplifying, and improving on the results presented in Harry Drickamer's original studies.

It is noteworthy that Percy W. Bridgman, who received the 1946 Nobel Prize in physics "for the invention of apparatus to produce extremely high pressures and for discoveries he made in the field of high pressure physics," recognized very early the exciting research potential of Drickamer's high-pressure work. In a 1960 letter professor Bridgman wrote to Harry Drickamer: "My sincerest congratulations on a masterpiece of design and execution. I had no idea that there were such potentialities for further development in the crude arrangements which I used myself. I envy you the adventure of the many further discoveries that you are certain to make with it." The International Association for the Advancement of High Pressure Science and Technology was formed some years after Bridgman's death, and the association established a prize in his honor. It was fitting that in 1977 Harry Drickamer was the first recipient of the Percy William Bridgman Award. The fact that Drickamer received 22 major awards, including awards from the American Chemical Society, the American Physical Society, and the American Institute of Chemical Engineers, illustrates well the major impact of his work on diverse fields of science and engineering.

Harry George Drickamer was born Harold George Weidenthal on November 19, 1918, to Louise Weidenthal and Harold Weidenthal in Cleveland, Ohio. His father died when Harry was very young, and after his mother remarried, Harry's stepfather, George Drickamer, adopted him. He was educated in the public schools of East Cleveland

and in his teens was very actively involved in sports, particularly baseball and football. In fact, after graduating from high school early he played minor league professional baseball in the Cleveland Indians farm system. As was typical for him, he wanted to succeed and to be the best, but with more experience in baseball he realized that playing in the big leagues would require a very special talent. Harry would have not liked to sit on the bench, and so he decided to quit baseball. Clearly, this decision determined his future career as a scientist and engineer. However, taking advantage of his athletic skills, he matriculated at Vanderbilt University on a football scholarship. As a result of an injury he soon transferred to Indiana University and then to the University of Michigan, where he enrolled in chemical engineering. He received a B.S. in chemical engineering in 1941 and one year later a master's degree in the same field. Harry was a successful and popular student, which led to his election as president of his class in the Engineering College.

A very important event in his life took place during these years: He met Mae Elizabeth McFillen, a nursing student at the University of Michigan, originally from Toledo, Ohio. Harry and Mae Elizabeth were married in New Orleans on October 28, 1942.

The next several years were pivotal in Harry Drickamer's professional career. In 1942 he took a position at the Pan American Refinery in Texas City, Texas. At this point he was not interested in pursuing a Ph.D. degree, but his fellow students played a prank on him by forging his name on a signup sheet for the Ph.D. qualifying exam in chemical engineering. Harry decided to take the 16-hour exam anyway. A couple of months later, after he started work in Texas, a notice came that he had passed the Ph.D. qualifying exam!

It was fortuitous that Harry Drickamer met another Harry, Harry Hummel, who was also starting work at Pan American with an M.S. degree from the University of Wisconsin. According to Harry Drickamer's own words, his new friend and colleague was much more sophisticated scientifically, and encouraged him to study physics and math. After solving many problems in physics and quantum mechanics, Harry Drickamer developed a taste for science and realized that he would like to become a scientist.

In addition to the 48-hour workweek, Harry Drickamer used a vapor liquid still at night and on Sundays to collect experimental data that the University of Michigan permitted him to use as a part of his Ph.D. thesis. The other part of the thesis was a plant test on an extractive distillation tower—the first of its kind in the world. Together with Harry Hummel, Harry Drickamer published this work, which led to the Colburn Award from the American Institute of Chemical Engineers in 1947. This research experience impelled him to finish his Ph.D. and to look for an academic position. In February 1946 Harry Drickamer returned to graduate school at the University of Michigan and received his Ph.D.

Because he was more interested in science than pure engineering, Harry Drickamer accepted a faculty position offer from the University of Illinois at Urbana-Champaign, where chemical engineering and chemistry were in one department. Obviously this was the right decision, as Harry Drickamer spent all his professional life at the University of Illinois. After his initial appointment as an assistant professor of chemical engineering in 1946, he was promoted to associate professor in 1949 and to full professor in 1953. In 1958 he was appointed professor of chemical engineering and physical chemistry, and in 1983 he became professor of chemical engineering, chemistry, and physics. In recognition of his major contributions to science and engineering he was appointed professor in the Center for Advanced Study at the University of Illinois in 1963. Indeed, his work encompassed the fields of chemical engineering, chemistry, and physics, and his 105 doctoral students were drawn from all the three departments: chemistry, chemical engineering, and physics.

At this point it is appropriate to mention Harry Drickamer's working habits. He used to visit all his students and postdoctoral fellows at least twice a day in the laboratory; in addition, the group met for afternoon tea or coffee, where they discussed not only research but also sports and current events. Saturdays and Sundays were working days for Harry. His former students recall how excited Harry Drickamer became when he heard about some new experimental results. His passion for research remained with him as long as he lived; several months before his death Harry was still enthusiastic and excited about a new project and shared with me his ideas during the morning coffee break we had enjoyed together for about 25 years. His students knew him as "Doc" and all of them recall fondly their experiences as graduate students in his laboratory. Many of his students became successful and prominent scientists. Election to the National Academy of Engineering, the National Academy of Sciences, and the American Philosophical Society represents some of the major honors received by his former students.

In 1995 Harry Drickamer's former students raised funds for a professorship in his honor, but he decided that it was more important to finance fellowships for graduate students in the departments of chemical engineering, chemistry, and physics. His influence on graduate education in these fields is illustrated by the fact that contributors to this fund were not limited to his own students but included others who had the opportunity to know him when they were students at Illinois.

Harry Drickamer's intense work habits still left him time to enjoy his family. He was very proud and involved with his five children, who are successful professionals: Lee, professor and head of biology at Northern Arizona University at Flagstaff; Lynn, technical library assistant in the Law Library at the University of Michigan; Kurt, professor of biochemistry at Oxford University in England; Margaret, professor of medicine at Yale Medical School; and Priscilla Atkins, a reference librarian at Hope College, Michigan, who is also a poet with more than 50 published poems. His three grandchildren were a source of great pleasure and joy to him.

Harry maintained his interest in sports and kept himself very fit, as he exercised on a treadmill and walked daily several miles to work and during the lunch hour. He never skipped his walks even during frigid Illinois winter days. To me, aside from science, he was a source of information about the intricacies of baseball, a sport I was ignorant about because of my Czech background. During our daily coffee breaks Harry also impressed me with his knowledge of U.S., English, and Greek history. His preferred reading was in history, particularly English history.

Harry George Drickamer died of stroke on Monday, May 6, 2002, in Urbana.

A survey of the main characteristics of his work is in order before a chronological narrative of Harry Drickamer's scientific accomplishments (478 publications). Harry's work encompassed a wide range of scientific problems; the common denominator was the innovative use of high pressure to obtain unique information about condensed phase phenomena. The diversity of problems and systems required the use of various spectroscopic and nonspectroscopic techniques. Consequently, Harry had to continue developing new instrumentation for his high-pressure experiments. The dynamic nature of his work is evident: Harry Drickamer explored and solved important problems in a specific field and then moved on to new areas. Although Harry was an experimentalist at heart, the goal of his experiments was to verify or test theories or to provide unique insights into topical phenomena. Harry's work was also influenced by his strong collaborations with his colleagues at Illinois. After joining the faculty at the University of Illinois, Harry Drickamer's early interests were in the area of fluids. Together with a radiochemist colleague, Robert Duffield, he designed an apparatus to measure radioactivity at high pressure and then studied the diffusion of molecules in liquids and gases.

In the period from 1955 to 1958, after he developed the unique instrumentation to investigate electronic spectra by optical absorption under high pressure, his initial studies dealt with transition metal ions and ligand field theory, absorption edges of Si, Ge, and a variety of II-V and II-VI compounds. According to Harry he was greatly encouraged by professors of physics Fred Seitz and John Bardeen, who took interest in this early work.

From 1960 to 1963 Harry Drickamer and his students developed instrumentation to measure electrical resistance at pressures of several hundred kilobars. At the same time Harry Drickamer started X-ray diffraction and Mossbauer resonance experiments at high pressure. The latter experiments were carried out in collaboration with professors Hans Frauenfelder and Peter Debruner from the Department of Physics. According to Harry another collaborator, professor of physics Charles Slichter contributed in a major way to the theoretical interpretation of the Mossbauer resonance experiments on changes of spin state and oxidation state of iron in inorganic compounds.

The series of investigations that had the broadest impact on solid-state physics were Harry Drickamer's studies of insulator-conductor transitions. In the period from approximately 1958 to 1963 he and his students carried out measurements of the optical absorption edge and electrical resistance of a variety of materials; they observed that with increasing pressure many of these materials became metals or narrow gap semiconductors. These insulator-to-metal transitions were observed in I_2, Si, Ge, Se, and in various compounds, using a combination of optical absorption and electrical resistance measurements. Electrical resistance studies on Ca, Sr, and Yb indicated that elevated pressures transformed them from metals to semiconductors and at even higher pressures transformed them back again into metals. Harry and his students observed such transitions involving alkali, alkaline earth, and rare earth metals. In addition, paramagnetic-diamagnetic, and ferromagnetic-paramagnetic transitions were observed in ferrous compounds and in iron. Many electron-donor complexes formed radicals that reacted to give chemical bonds of new types, and photochromic materials became thermochromic.

In the 1970s Harry's group developed techniques for studying luminescence in liquid solutions at pressures of 12 kilobars and carried out a variety of studies that tested theories of the effect of viscosity, dielectric constant, refractive index, and freezing on luminescence peak energy, intensity, and lifetime. As an example of yet another unique collaboration, Harry with Professor Gregorio Weber (Department of Biochemistry) investigated the effects of pressure on protein conformation, using intrinsically fluorescent amino acids and fluorescent ligands. These pioneering experiments opened a new approach in the field of protein folding.

Currently there are at least 25 laboratories around the world applying high-pressure fluorescence techniques to the investigation of biomolecules.

In the period from 1986 to 1990 Harry's group continued earlier studies, using optical absorption to study changes in molecular conformation in the ground state, in crystals and rigid polymers, including photochromic and thermochromic organic molecules, molecules with metal-to-metal bonds, and a variety of complexes involving transition metal ions with ligands.

Between 1990 and 1993 Harry and his students published a series of papers on thermoluminescence in doped ZnS phosphors, in irradiated alkali halide crystals, in crystalline quartz, and in coronine. In the case of ZnS phosphors, which are of considerable technological interest, the first identification of so-called deep levels and the elucidation of their behavior had important commercial implication. High-pressure luminescence experiments were also used to characterize molecular interactions in polymeric materials, including tests of theories of energy transfer between molecules, the effect of modifying ligands in organometallic compounds, and the study of molecules that can exhibit more that one conformation in the excited state.

Regarding the theoretical aspects of his work, it should be emphasized that Harry Drickamer's high-pressure experiments provided tests of many important theories, including Bethe's ligand field theory, Van Vleck's theory of the high-spin to low-spin transition, the Forster-Dexter's theory of energy transfer in phosphors, and Mulliken's theory of electron-acceptor complexes. Harry's pressure studies on Ni^{2+} in NiO were in good agreement with the predictions of Bethe's point charge model. High-pressure Mossbauer resonance studies allowed a direct test of Van Vleck's prediction that as the ligand field increased, it would become energetically favorable to pair the spins of d electrons in violation of Hund's rule. Indeed, high-spin to low-spin transitions were induced by pressure. Radiationless transfer of optical excitation is an important process in various applications, such as photosynthesis and fluorescent lighting. According to the Forster-Dexter theory the efficiency of transfer is increased as r^{-6} where r is the donor-acceptor distance, and is proportional to the overlap of donor emission and acceptor absorption peaks. As both these parameters change significantly with pressure, Harry's high-pressure studies found that the theory is remarkably quantitative.

An overview of Harry's research accomplishments would not be complete without a discussion of his pioneering contributions to high-pressure instrumentation. In the early 1960s Harry designed and built an optical cell with a special optical window that could be used up to 12 kilobars. Today many laboratories continue to use this superior window design for absorption, luminescence, infrared, and Raman studies on liquids, gases, and supercritical fluids.

In 1930 Bridgman invented the principle of massive support; in the middle 1950s Harry extended this design to include support on the taper as well as the flat. Using this technique he was able to carry out optical absorption and luminescence studies up to 150 kilobars. Further extensions of this design from 1959 to 1965 permitted the first electrical resistance, X-ray diffraction, and Mossbauer studies up to 200-300 kilobars.

Many of Harry's high-pressure experiments produced results of technological importance but the experiments on semiconductor heterostructures and quantum well heterostructures, carried out with Nick Holonyak, Jr. (John Bardeen Chair and professor of electrical and computer engineering and physics) and their collaborators deserves special mention. The measurements of the pressure dependence of AlGaAs light-emitting diodes, near the direct-indirect transition, established definitive design limits (crystal composition) for high-brightness red-spectrum heterojunction LEDs. The absorption measurements carried out at high pressures on AlAs-AlGaAs superlattices provided special insights into semiconductor lasers, and represented the first high-pressure experiments on quantum well devices.

Harry Drickamer received many honors and awards for his pioneering and seminal work in several different fields of science and engineering. As an illustration I include citations from a few awards to show Harry's impact on chemistry, chemical engineering, and physics.

American Physical Society, 1967 Oliver E. Buckley Solid-State Physics Prize: "for experimental inventiveness, originality and physical insight leading to significant results on the effects of extreme pressures on electronic and molecular structures of solids."

American Society for Engineering Education, 1968 Victor Bendix Award: "for his contribution in engineering education and, in particular, his leadership in educating engineers who entered into the new field of the design of solids."

American Chemical Society, 1987 Peter Debye Award in Physical Chemistry: "for the development of high pressure as a widely applicable independent variable of central importance in the generation of physical chemistry that is crucial to the exploration of theories of phenomena in solids and liquids."

1987 Robert E. Welch Prize in Chemistry: "for his outstanding contributions to chemistry and all sciences concerned with the study of matter."

I WOULD LIKE to acknowledge Mae Elizabeth Drickamer for permitting me access to all the materials pertaining to the personal and research life of Harry George Drickamer.

PRINCIPAL AWARDS AND HONORS

1965 Member of the National Academy of Sciences
1970 Fellow of the American Academy of Arts and Sciences
1979 Member of the National Academy of Engineering
1983 Member of the American Philosophical Society

1947 Coburn Award, American Institute of Chemical Engineers
1956 Ipatieff Prize, American Chemical Society
1967 Oliver E. Buckley Solid-State Physics Award, American Physical Society
Alpha Chi Sigma Award, American Institute of Chemical Engineers
1968 Victor Bendix Award, American Society for Engineering Education
1972 William H. Walker Award, American Institute of Chemical Engineers
1974 Irving Langmuir Award in Chemical Physics, American Chemical Society
1977 P. W. Bridgman Award, International Association for the Advancement of High Pressure Science and Technology
1978 Michelson-Morley Award, Case Western Reserve University
1983 Chemical Pioneers Award. American Institute of Chemists
1984 John Scott Award, City of Philadelphia
1985 Outstanding Materials Chemistry, U.S. Department of Energy
1986 Alexander von Humboldt Award, Federal Republic of Germany
Warren K. Lewis Award, American Institute of Chemical Engineers
1987 Peter Debye Award in Physical Chemistry, American Chemical Society
Robert A Welch Prize in Chemistry, Welch Foundation
Distinguished Professional Achievement Award, University of Michigan
1988 Elliott Cresson Medal, Franklin Institute
1989 National Medal of Science
Award for Outstanding Sustained Research, U.S. Department of Energy

1994 Doctor of chemical science honoris causa, Russian Academy of Science
1996 Gold Medal, American Institute of Chemists

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