Jim Zimmerman and the SQUID

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Abstract— **The career of Jim Zimmerman, beginning with a solid foundation in electronics and cryogenics, reached a turning point in 1965 when he became coinventor of the rf SQUID (Superconducting QUantum Interference Device), while working at the Scientific Laboratory of the Ford Motor Company in Dearborn, Michigan. Recognizing the exquisite sensitivity of the SQUID as an amplifier and magnetometer, Zimmerman devoted the remainder of his career, at Ford and later at the National Bureau of Standards, to the further development of the SQUID and its applications. In 1969, Zimmerman also helped found SHE Corporation, which marketed the first commercially successful SQUID. While at NBS, Zimmerman introduced two variations, the SQUID gradiometer and the fractional-turn SQUID, to enhance the sensitivity of SQUIDs in special situations. He also developed an improved understanding of SQUID dynamics by exploring the pendulum analog using carefully made models, work that has benefited a generation of students. Putting the SQUID to work, Zimmerman investigated applications in metrology, biomagnetism, and geophysics. Notably, he participated in collaborations that recorded the first magnetocardiogram made with a SQUID and the first magnetoencephalogram of an evoked auditory response. Later, Zimmerman explored closed-cycle refrigeration as a means of making SQUIDs more useful outside the laboratory environment, and in 1977 he demonstrated an operating SQUID cooled to 8.5 K by a Stirling-cycle refrigerator made largely of plastic. Zimmerman is remembered for his keen physical insight, the elegance and simplicity of his experiments, and his willingness to question conventional wisdom in all aspects of life.**

I. Early Years

James Edward Zimmerman was born on 19 February 1923 at Lantry, South Dakota. His father was a farmer and sheep rancher, keeping about 300 head on land that was part of the Cheyenne River Indian Reservation. Jim grew up with two brothers and two sisters on the desolate wind-swept prairie and, according to his recollection, spent much of his childhood keeping the coyotes away from the sheep. Jim hated school with a passion, but during high school he became interested in radio and read everything he could find about electronics. He built receivers and transmitters using parts scavenged from broken radios and studied circuit theory until he understood how radios worked, from antenna to output amplifier.

After Zimmerman graduated from Dupree High School in 1939, he moved on to the South Dakota School of Mines and Technology in Rapid City and began to study electrical engineering in earnest. Given his familiarity with radio, the curriculum at the School of Mines was not difficult, and Jim received his bachelor of science degree "With Highest Honors" in February of 1943. He graduated a few months early owing to an accelerated schedule implemented during World War II.

Soon after graduation, Zimmerman became part of the war effort when he joined the Westinghouse Research Laboratory in East Pittsburgh to work on microwave radar. During 1943, Jim helped design transmit/receive switches and other components for 1 and 3 cm radar. In 1944, he was selected to be the Westinghouse representative to an Australian radar group being formed at the MIT Radiation Laboratory in Cambridge, Massachusetts. This group, which also included a representative from Western Electric and five from MIT, first assembled at the Radiation Laboratory, and Jim remembered briefly using the desk of Hans Bethe, while Bethe was out of town. Early in 1944, the group traveled to Australia to execute its assigned task of assisting the Australian radar effort. Although civilians, members of the group were given a simulated military rank in case of capture by the Japanese, and Jim was made a lieutenant. He worked at the Radio Physics Division of the Council for Scientific and Industrial Research (CSIR), in a laboratory located on the campus of the University of Sydney. While in Sydney, Zimmerman designed a bolometer for measuring microwave power and a transmit/receive switch for the 10 cm band. Also in Sydney, Jim met and married Jean McLeod, an Australian.

In May of 1945, with the end of the war in sight, Jim was recalled to the U.S., and he temporarily parted with Jean. Jim left Westinghouse when the war ended in the fall of 1945 and enrolled as a graduate student in physics at the Carnegie Institute of Technology (later Carnegie-Mellon University). His wife joined him in Pittsburgh after his first semester in graduate school. However, because they were short of money and Jean was unhappy in America, Jim dropped out of school, and they returned to Sydney early in 1946.

In Australia, Zimmerman joined the Heat Division of CSIR and became head of the photometry section, with three employees under his direction. Jim's lab was located at the other end of the same building at the University of Sydney in which he had worked during the war. The photometry section was charged with routine tasks such as the calibration of standard lamps, but the group also worked on a photometer for testing blood by measuring its absorption spectrum. Jim remembered that they all donated many drops of blood to the cause. A daughter, Janet, was born to Jim and Jean in March of 1947.

Still wanting to complete his doctorate, Zimmerman returned to the U.S. in the spring of 1948 and enrolled again at Carnegie Tech. Jean followed Jim back to Pittsburgh somewhat later but was again unhappy in the U.S. and returned to Australia shortly after she arrived. Jim and Jean eventually parted ways, and Jean raised their daughter on her own in Australia.

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At Carnegie Tech, Zimmerman worked under Immanuel Estermann, an outstanding teacher and experimentalist in a variety of fields. Under Estermann, Jim began to learn cryogenics, the science and technology of low temperatures. He held the Gerard Swope Fellowship during the 1950 academic year and completed his doctoral thesis in 1951 on the topic of "Heat Conduction in Alloys and Semi-Conductors at Low Temperatures." This work was later published in the *Journal of Applied Physics* [1].

Zimmerman stayed on at Carnegie Tech as a research associate for two years after receiving his doctorate. During this time, he set up one of the first Collins helium liquefiers and operated nitrogen and hydrogen liquefiers as well, in support of the cryogenics program at Carnegie. Jim also continued to do research, measuring specific heats of metals with Howling and Mendoza [2] and demonstrating the existence of a predicted component of the lattice heat conduction that is linear in temperature, observed in high-resistivity alloys. In 1953 Jim married Ida Caporali, who became his constant companion from that time onward.

Later in 1953, Zimmerman accepted a position with the Smithsonian Institution and moved to California to become an assistant at the Table Mountain Observatory in the San Gabriel Mountains north of San Bernadino. This observatory was part of a program, begun around the turn of the century by Smithsonian director C.G. Abbott, to routinely measure the "solar constant," the energy flux of the sun corrected for atmospheric absorption. After nine months learning the ropes at Table Mountain, Jim was reassigned to the Montezuma Observatory in the Atacama Desert of northern Chile, one of the driest places on earth. Jim was the observatory director in Chile and, together with an assistant, was responsible for daily measurements of the solar constant, weather permitting. While in Chile, Jim owned a motorcycle, which he used for trips into the mountains to escape the barren landscape of the observatory. In 1955, however, after Jim had been in Chile for fifteen months, Fred Whipple of Harvard was appointed director of astronomy at the Smithsonian, and the solar-constant program was terminated.

II. Ford

Soon after returning to the U.S., Zimmerman received a letter from Jack Goldman, a former collaborator of Estermann, offering him a position with the low-temperature group at the Scientific Laboratory of the Ford Motor Company in Dearborn, Michigan. While he might have elected to stay on at the Harvard Smithsonian Observatory, Jim accepted Goldman's offer and switched from astronomy back to cryogenics, a discipline that would be central to his career.

Beginning in 1955 and for the next eight years, Zimmerman's work at Ford was reminiscent of his doctoral thesis. He measured the thermal, electrical, and magnetic properties of a variety of metals and alloys at low temperatures. During this time, Zimmerman also published several papers on cryogenic techniques and apparatus, from a liquid-helium level indicator to a cyclic magnetic refrigerator that reached 0.2 K using a superconducting solenoid [3].

Jim's work at Ford suddenly changed direction in the early 1960's, when he became involved in experiments related to quantum effects in superconductors and began work that would eventually make him a coinventor of the rf SQUID, or radio-frequency biased superconducting quantum interference device. The initial impetus for this work was an experiment carried out at Ford by John Lambe in late 1962 or early 1963. During experiments on nuclear magnetic resonance at frequencies around 10 GHz, Lambe noticed that the rf impedance of a fragment of indium used in an electrical contact varied periodically as a function of an applied magnetic field. The periodicity of the effect was one or two nanotesla, indicating that the device was extremely sensitive to magnetic fields. Indeed, Lambe's experiment easily detected the change in field resulting when a steel chair was moved anywhere within the room. As Zimmerman has written [4] "This exciting observation was so puzzling that at one time I was consulted for suggestions as to the fundamental nature of the phenomenon and how to investigate it experimentally. I was able to shed not the faintest light on the subject."

The Ford group understood that the wonderful sensitivity of Lambe's experiment probably resulted from effects related to the quantization of magnetic flux, observed experimentally for the first time in 1961 [5], and possibly to superconductive tunneling effects predicted by Josephson in 1962 [6]. In fact, Lambe had probably created by accident a device that was essentially an rf SQUID. While the indium-contact experiment was not well understood and could not be published, the Ford group knew that they had discovered something important and began looking for simpler ways to realize the effect.

The first practical realization of a SQUID occurred at Ford about a year after Lambe's initial experiment and was inspired by the work of John Rowell at Bell Telephone Laboratories. In September of 1963, Rowell published a paper describing the observation of a "diffraction pattern" that resulted when a Josephson tunnel junction was subjected to a magnetic field [7]. When the Ford group saw the paper, they realized that Rowell's result was analogous to single-slit diffraction and that much greater sensitivity to magnetic fields would be obtained if two junctions were connected in parallel by a superconducting loop, to create the analog of a two-slit interference pattern. Robert Jaklevic had already been making tunnel junctions at Ford, and, thinking that Bell Labs would pursue the same idea, worked quickly to fabricate the required structure. As it turned out, the competition from Rowell was only imagined, and Jaklevic, Lambe, Arnold Silver, and James Mercereau at Ford had the honor of inventing and demonstrating the first two-junction, dc-biased SQUID [8].

Up to this point, Zimmerman was merely an interested observer of the work on quantum interference at Ford. However, shortly after Jaklevic *et al.* demonstrated the dc SQUID, Jim suggested a new approach to making the required junctions. At the time, Jim was working on a control mechanism for power steering in automobiles that used pressure-sensitive resistive contacts. He thus knew that the resistance of a contact between two pieces of metal is roughly $R = \rho/D$, where ρ is the resistivity of the metal and D is the diameter of the contact. This led to the suggestion that superconducting weak links of suitable resistance might be formed by small-area pressure contacts. Working with Silver, Zimmerman was able to make a dc SQUID simply by placing a bent niobium wire across a niobium ribbon, so that the wire contacted the ribbon on each edge. This simple arrangement revealed the same kind of interference pattern as the earlier thin-film devices and ushered in an era of Josephson junctions made with point contacts [9]. The wire and ribbon SQUID was also the first to use a hard, type II material and the first to allow adjustment of the junction critical current. In this case, the tension on threads tied to each end of the niobium wire provided a crude adjustment, rather like the cat's whisker of an early crystal radio.

The niobium wire experiments, which revealed a remarkably simple approach to SQUIDs, were completed in just a few days and began a highly productive collaboration between Zimmerman and Silver that would continue for the next five years. These experiments are also typical of Zimmerman's approach to science. Reducing a complex situation to its essentials, Jim often arrived at a simple approach, requiring a minimum of apparatus, that provided as much insight as the elaborate and sophisticated experiments of others. Very quickly, the experiments with wires led Zimmerman to point contacts consisting of 000–120 niobium screws that allowed a more reproducible adjustment of the junction's critical current and permitted fabrication of a variety of practical SQUIDs [10].

The next step on the road to the rf SQUID was taken in early 1964 by Lambe, Silver, Mercereau, and Jaklevic, who investigated the behavior of a thin-film, two-junction SQUID in a 9.4 GHz microwave field [11]. As in the earlier indium-contact experiments, the microwave impedance of the two-junction device was found to vary periodically with applied magnetic field, but a full understanding of the mechanism was still lacking.

The two-junction device was certainly a kind of rf SQUID, but it was unnecessarily complicated. Sometime after this work, Silver suggested to Zimmerman that an rf field could be used to modulate the flux passing through a superconducting loop with just one junction. At that point there was some confusion about whether inductive coupling would modulate the flux in the loop in the absence of a direct connection. However, Jim's electrical engineering experience immediately told him that a coil placed inside the superconducting loop would modulate flux in the loop and that the rf losses would depend on the applied field, because it determines whether or not the junction's critical current is exceeded and flux is allowed to shuttle in and out of the loop. With this insight, Jim realized that the rf SQUID was functionally similar to a class C amplifier, a circuit he had studied during his high-school radio days. Thus, the essential idea of the rf SQUID was understood only after the basic effect was observed accidentally in an indium contact and under more controlled but still complex circumstances in a two-junction device. Silver and Zimmerman published their first paper on the canonical single-junction rf SQUID in December of 1965 [12].

The term "SQUID" was not used in the early papers on interference devices, although the phrase "superconducting quantum interference magnetometer" appeared in a 1966 paper [13]. Zimmerman remembered that they began using the abbreviation "QID" for "Quantum Interference Device" but that he and Silver discussed the matter one day and agreed on "SQUID" as an appropriate acronym for "Superconducting QUantum Interference Device." After that, they used "SQUID" so routinely in conversations that the term was picked up by other groups, and it was first used in print by Forgacs and Warnick, also of Ford, later in 1966 [14]. Today, the term"SQUID" can be found as an entry in the *Oxford English Dictionary.*

In 1967, the SQUID group at Ford began to break up due to internal dissension. In particular, Zimmerman felt that Mercereau had gained more than his fair share of credit by giving a series of lectures around the U.S., almost one per week over the span of a year, while contributing very little in the lab [15]. The impression given to people outside of Ford led Philip Anderson of Bell Labs to suggest that superconducting quantum interference be called the "Mercereau effect" [16]. In November of 1967, spurred by such difficulties, Zimmerman left Dearborn for a position at the Aeronutronics Division of Philco–Ford in Newport Beach, California.

At Aeronutronics, Zimmerman became manager of the cryoelectronics section and continued to work on SQUIDs. During his two years in California, Jim made important progress by gaining a more complete understanding of the mechanism of the rf SQUID. In particular, he realized that its properties could be fully understood simply by using the Josephson equations (Stewart-McCumber model) to represent the weak link. The resulting publication [17] has received more citations than any of his other papers. The realization that the SQUID is well described using the Stewart-McCumber junction model also led Jim to begin thinking in terms of a mechanical analog, in which the dynamics of a junction is represented by that of a pendulum. This analogy was pointed out by Anderson as early as 1963 but had been largely ignored [18]. Later, Zimmerman and Donald Sullivan made this insight accessible to a wide audience by building pendulum models and demonstrating equivalent behaviors important in Josephson phenomena [19].

In 1969, while still at Aeronutronics, Jim joined with John Wheatley, Olli Lounasmaa, and Jeremy Good to start a company called SHE (Superconducting Helium Electronics). John Wheatley was the organizer, but each of the founders contributed $5000 in initial capital. The idea of SHE was to manufacture both SQUIDs and helium-3 refrigerators. Zimmerman designed the first SQUID system sold by SHE, based on the published niobium-screw point-contact devices he had introduced at Ford. This device and its successors became the first commercially successful SQUIDs, and SHE (later renamed BTI, Biomagnetic Technologies Incorporated, when biomagnetic sensors became its primary product) has remained a leader in the field of superconducting electronics. However, Zimmerman dissolved his relation with SHE about two years after it was founded, due to a possible conflict of interest with a job he had taken at the National Bureau of Standards (NBS).

The offer of a job at the NBS laboratory in Boulder, Colorado came late in 1969. Before joining NBS, however, Jim made an important detour, taking him to the National Magnet Laboratory at MIT. The trip resulted when Edgar Edelsack of the Office of Naval Research, who was funding Jim's research at Aeronutronics, suggested a collaboration with David Cohen, another recipient of ONR funds, who was attempting to measure the magnetic field of the human heart. At the end of 1969, Zimmerman and Edelsack joined Cohen at MIT to try an experiment. On the way to Cambridge, Jim stopped in Boulder long enough to assemble a SQUID, then carried his apparatus to Boston on the plane. After two days of scrambling to find a suitable Dewar and set it up in Cohen's newly completed shielded room, they were ready to make a measurement. Jim stripped down to his shorts to avoid stray magnetic fields from metallic fasteners, sat next to the magnetometer, and became the first subject of a SQUID based measurement of the magnetic field of the human heart. This was on New Year's eve, December 31, 1969. The results, published in April of 1970 [20], marked the beginning of what would become a long and fruitful association between SQUIDs and biomagnetism.

III. NBS

After joining NBS in January of 1970, Zimmerman became an advocate of SQUIDs for a variety of applications, including metrology, geomagnetism, and biomagnetism. Later, he would focus his attention on the development of low-power, closed-cycle refrigerators, often called cryocoolers, tailored to cooling SQUIDs. During his fifteen years at NBS, the bulk of Jim's work was funded by contracts from the Office of Naval Research, through Edgar Edelsack.

Early on at NBS, Jim had two original ideas for improving SQUID magnetometers. First, he conceived of using the SQUID with a flux transformer having two oppositely oriented coils to measure the gradient of the magnetic field. Because a gradiometer is insensitive to uniform fields, it responds primarily to nearby sources and effectively filters out distant sources of noise. Using a gradiometer, Zimmerman and Frederick were able to record a magnetocardiagram in the absence of magnetic shielding [21]. Second, Jim had an idea for making a SQUID with enhanced sensitivity that he called a fractional-turn SQUID [22]. In general, the response of a SQUID scales as the magnetic energy Φ_0^2/L, where Φ_0 is the flux quantum and L is the inductance of the SQUID loop, and avoiding thermal noise requires $\Phi_0^2/L \gg k_B T$. Thus, a good signal-to-noise ratio results when L is small, but coupling external fields to a small inductor is difficult. Jim's solution to this problem was a SQUID loop consisting of several large inductors connected in parallel to provide ample coupling area while keeping the net inductance small. This elegant method of enhancing sensitivity has since been reinvented by several other workers.

One of the first applications of the fractional-turn SQUID magnetometer was to geomagnetic measurements, and on two occasions Zimmerman collaborated with Wallace Campbell of the U.S. Geological Survey. In June of 1973, they traveled to Chad in Africa to measure the earth's magnetic field during a solar eclipse. The idea was that an eclipse would perturb a normal ionospheric current, called the equatorial electrojet, which flows along the magnetic equator. This current should be diminished during an eclipse because the shadow cast by the moon will reduce the local ionization. However, the measurements made in 1973 at the Fort Lamy (now Ndjamena) airport were taken during a peak in the sun-spot cycle, and there was too much background noise to distinguish the small effect of the eclipse [23].

On another occasion, in August of 1978, Jim traveled to Alaska with Campbell in order to measure currents in the Alaskan oil pipeline induced by the polar electrojet, the effects of which are usually observed as the northern lights. They set up a SQUID gradiometer a few feet from the pipeline at a section near Fairbanks where the pipeline is above ground, hoping to see fluctuations in pipeline current correlated with the aurora. In this instance, there was not enough sun-spot activity to observe either the aurora or the desired effect [24].

In 1975 Jim began a collaboration with Martin Reite of the University of Colorado Health Sciences Center in Denver to measure the magnetic field of the brain. Magnetoencephalography (MEG) with SQUIDs was in its infancy at the time, but Cohen had performed the first such experiment in his magnetically shielded room at MIT in 1972 [25]. Jim decided that it wasn't necessary to build an expensive magnetic shield of the kind used by Cohen. Because the signals of interest are at a few hertz, it is sufficient to screen out fields in this frequency range, something that could be done using the eddy-current shielding from a 2-inch thickness of aluminum, according to Jim's back-of-the-envelope calculation. Zimmerman built a suitable room at NBS, and by 1976 Riete, Zimmerman, Jochen Edrich, and John Zimmerman had observed correlations between their MEG measurements and conventional electroencephalography (EEG) [26]. Two years later, this group observed for the first time an evoked auditory response by MEG and determined that the response was from the part of the brain known to be associated with the sense of hearing [27]. For many years after this initial collaboration, Zimmerman continued to act as a consultant to Reite's research group.

In the mid 1970's, Zimmerman began to think about closed-cycle refrigeration as a means of making SQUIDs more useful outside the laboratory environment. He quickly learned that commercially available refrigerators were poorly suited to the job. Because SQUIDs dissipate very little power, Jim realized that they can be cooled with a much smaller refrigerator than is required for other applications. In addition, if the SQUID is to be used as a magnetometer, the refrigerator must be made of nonmagnetic materials, a feat that had not previously been attempted. Jim guessed that a refrigerator about the size of a bicycle pump would be sufficient to cool a SQUID, and calculations confirmed his intuition. Thus, Zimmerman set about building a low-power, Stirling-cycle refrigerator made largely of plastic. In 1977, working with Ray Radebaugh, Jim demonstrated a refrigerator with a four-stage nylon displacer that achieved a temperature of 8.5 K, just low enough to operate a niobium SQUID [28]. This low-power refrigerator, often called a cryocooler, looked remarkably like a bicycle pump.

Zimmerman continued to work on Stirling-cycle cryocoolers for several years, but the goal of achieving reliable operation in a device suitable for cooling SQUIDs remained elusive. However, Jim's initial success prompted many others to enter the field, and the cryocooler conferences that he sponsored at NBS in 1977 and 1980 initiated a series of meetings that have grown to become the International Cryocooler Conference, a regular biennial event.

In November of 1985, at the age of 62, Zimmerman chose to retire. Jim accomplished many things of outstanding significance during his fifteen years at NBS and received a number of awards for his work. In 1975, he was awarded a Department of Commerce Gold Medal for "innovative contributions to practical precise measurements using superconducting quantum interference devices." In 1978 his work on cryocoolers was recognized with a NBS Special Achievement Award, and in 1979 he received the Samuel Wesley Stratton Award, the highest award for scientific achievement conferred by NBS, for "pioneering developments of superconducting quantum interference devices and refrigeration support systems for them, and for energetic application of superconducting magnetic sensors in diverse fields." Finally, in 1983 Zimmerman was made an NBS Fellow.

Zimmerman's career in cryogenics did not end with retirement however. Just before Jim left NBS, he began working with Ray Radebaugh on an exciting new idea for low-temperature refrigeration. In reading the paper of a Russian group headed by Mikulin [29], Radebaugh realized that pulse-tube refrigerators, which are intrinsically reliable because they do not require moving parts at cryogenic temperatures, could be pushed to much lower temperatures than had previously been attained. Thus, Jim participated in the construction of the first pulse-tube refrigerator to achieve a temperature of 60 K, and returned to continue this work on contract after he retired. The group's initial work on pulse-tube devices was sufficiently innovative that it received the Russel B. Scott Outstanding Paper Award at the 1987 International Cryogenic Engineering Conference [30].

In 1987 Zimmerman was induced to reconsider the SQUID when superconductivity was reinvigorated by the discovery of ceramic materials with transition temperatures exceeding the boiling point of liquid nitrogen. Returning to NBS as an unpaid guest worker, Jim began to work with pressed pellets of yttrium barium copper oxide (YBCO) fabricated by James Beall and Ronald Ono. The situation must have reminded Jim of his early work with niobium-wire SQUIDs at Ford, and he took a similar simple and direct approach. Gluing a round pellet into an aluminum frame to support the easily fractured material, Jim found that he could drill a hole through the center and then break the pellet along a radius to form a loop with a single weak link. Ono remembers that Jim suddenly announced that they had an rf SQUID when he noticed that the oscilloscope trace was sensitive to the position of his chair, echoing events at Ford more than twenty years earlier. Although published accounts of dc SQUIDs made from YBCO had just appeared, the NBS group was able to claim the first rf SQUID operating at the temperature of liquid nitrogen [31].

The advent of high-temperature superconductivity (HTS) also brought the need for a simple way of achieving variable temperatures in a range extending from 4 to 100 K or more, suitable for testing HTS materials and devices. Working with Arnold Silver again after more than twenty years, Jim suggested using a liquid helium cryostat with a valve at the top to control the rate at which helium is allowed to leak in at the bottom [32]. With feedback control, this system can achieve temperature regulation to about 1 mK, more than adequate for routine testing of HTS devices. Jim and his grandson Jason Lee, then a student of electrical engineering at the University of Colorado, made the first half dozen such cryostats in Jim's home, under contract with TRW. Later produced commercially in larger quantities, the Z-cryostat ("Z" for Zimmerman) is now a standard apparatus in HTS laboratories.

An important part of Jim's career has been the cultivation of long-term friendships with colleagues in other countries. In particular, Jim has maintained a friendship with Olli Lounasmaa of Finland since meeting him during the early days of SQUIDs. At Lounasmaa's invitation, Zimmerman visited Helsinki Technical University for extended periods on several occasions to consult and present lectures. Jim particularly remembered a visit during January and February of 1979 when he learned many of the fine points of cross-country skiing. During these visits, Jim also formed a lasting friendship with Toivo Katila, who leads an active biomagnetism group in Helsinki. Similarly, Zimmerman has been a close friend of Paulo Costa Ribeiro of the Catholic University of Rio de Janeiro since 1970 and has returned to Brazil to serve as a visiting professor for extended periods on many occasions, totaling more than two years, principally in Rio but also at branches of the University of São Paulo in São Carlos and Ribeirão Preto. More recently, in 1987, Zimmerman was the guest of Christoph Heiden for six months at the University of Giessen in Germany, under the sponsorship of an Alexander von Humboldt Senior Fellowship, and this also led to a lasting friendship.

Although Jim's research touched some of the most intriguing mysteries of quantum physics, his colleagues knew him as a source of simple insights and elegant experiments that cut to the quick with a minimum of apparatus. Indeed, Jim was a master of simplification, often working with materials like dental floss and rubber bands, where others applied high technology. It was Jim's genius to lay bare aspects of quantum reality using bits of niobium wire and masterful insight.

Zimmerman died in Boulder on 4 August 1999 after battling cancer for three years.

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