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On 2 May 1994, Alfred O. C. Nier, Regents Professor of Physics Emeritus at the University of Minnesota, was returning home from work when he suffered severe injuries in an automobile accident. Two weeks later, on 16 May, he died just a few days before his eighty-third birthday. During his time in the hospital, the second A.O.C. Nier Symposium at Durango, Colorado, was in session, a meeting he had planned to attend. From his hospital bed in Minneapolis he was able to listen to the eloquent speech by Professor John De Laeter of Perth, Western Australia, who paid tribute to Al Nier, a scientist of the highest stature and a human being with many friends and admirers around the world. "It's the magic of Nier," explained one organizer about the large attendance at the symposium.

Al Nier was born in St. Paul, Minnesota, on 28 May 1911 as the only son of German immigrants; his only sister was eleven years older. He quickly learned from his parents that hard work will always pay off. As a youngster he was responsible for a paper route to earn some money to buy tools and gadgets he could use to satisfy his technical curiosity. The radio in its infancy captured Al's attention, and soon he built his own unit. Although his parents had only a modest family income from a small dry-cleaning business, they were convinced that Al should pursue a path of higher education.

Al Nier's scientific career was very closely associated with the physics department at the University of Minnesota. Initially, he started in 1927 as a student in electrical engineering. After completion of bachelor's and master's degrees, he switched to physics for his Ph.D. work. He was fortunate to have as his advisor John Tate, who introduced him to atomic and molecular physics and recommended a new research tool, the mass spectrometer. Al became very attached to this technique of mass separation and isotopic studies, and never lost his interest in and enthusiasm for finding new applications in many areas of science, not just physics. It became his instrument of choice, the only instrument he extensively used and changed to perfection. On the one hand, he designed and operated one of the largest mass spectrometers, with a

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16-inch radius, located in the basement of the physics building, and on the other hand, one of the smallest, with a radius of only one inch. This latter actually made it to the planet Mars. In his Ph.D. work between 1933 and 1936 the instrument was one of the early 180° magnetic instruments. Al finally decided to work on problems in nuclear physics, which was emerging as an exciting new field. He measured the relative isotope abundance of five elements (Ar, K, Zn, Rb, Cd) and discovered the existence of the radioactive isotope ^{40}K, which later became a key element for making geological age measurements.

After his graduation in 1936, Al Nier left for Harvard University with a National Research Council fellowship to work with Kenneth Bainbridge on mass spectrometer studies investigating the heaviest elements. At Harvard he started to construct a large instrument superior to others, to open the entire atomic table for isotope studies, including those of lead and uranium. Both are critical elements in geological age measurements. In 1938, he returned as an assistant professor of physics to the University of Minnesota. Very productive years followed in mass spectrometry, which moved Minnesota to the forefront of isotope research. One of the significant accomplishments during this time was the development of a new mass spectrometer with a 60° sector magnet replacing the very heavy 180° magnet used in all other spectrometers. The new Nier-type mass spectrometer was born. Together with a Nier-type ion source, it contained all essential ingredients for an excellent analysis system used by scientists in research and industry for decades to come. With colleagues in biology, physiology, and medicine he also started to use the instruments to analyze samples containing carbon-12 and -13. The research field employing isotope tracers was born. Without any doubt, a highlight in his career was the separation of ^{235}U and ^{238}U upon the request of Enrico Fermi.

After World War II, numerous papers with Walter H. Johnson and others show his tremendous progress in precision mass measurements and in the discovery of isotopes. His scientific accomplishments were accompanied by new technical progress in mass spectrometer operations and in vacuum physics. An excellent machine shop in the department supported his research activities, and a number of papers with the shop manager, B. Thorness, signify technical and scientific progress. His friendship with Josef Mattauch, who was a director of the Max-Planck-Institute in Mainz and an accomplished mass spectroscopist, was very important to Al. Together they proposed the new unified mass scale based on carbon-12, and they maintained a friendly competition in mass measurements between Mainz and Minneapolis. Whenever Al was in Europe, he visited his old friend after Mattauch retired.

Al was moved and saddened when he found him in very poor health and under adverse living conditions.

Al Nier always liked to work in frontier areas of science. In the early sixties, space research provided the excitement of flying instruments on rockets and satellites and exploring the Earth's upper atmosphere and the atmospheres of other planets. He took the challenge to design and build very small mass spectrometers that could withstand the vibration of a rocket burn and the hostility of the environment in short- or long-duration space flights. With his students and the technicians in the physics shops, he developed the first technically and scientifically sophisticated rocket payload carrying three mass spectrometers with open and closed ion sources to explore the fringes of the Earth's atmosphere above 100 km. Although the data analysis of a spinning rocket was a challenge to his students, early results showed in great detail the separation of gases in the Earth's atmosphere above 100 km and the rapid rise in gas temperatures. Large-scale changes in helium and the dominance of atomic oxygen were other important discoveries from the early rocket flights.

His upper atmosphere research work proliferated when a series of the very successful atmosphere explorer satellites (AES), each carrying his instrument among others, was launched. The open source neutral mass spectrometer from the University of Minnesota contributed particularly to the measurements of atomic oxygen and nitrogen, and to an understanding of variations in gas densities due to changes in solar activities never observed before.

Al Nier's own unique contributions to the AES program were manifold. He selected the Mattauch-Herzog design for the mass spectrometer, not his own instrument. This wise decision allowed him to fly a multiple collector system and thus expand the detection capability. Furthermore, he employed a simple and effective technique through ion source modifications to separate in the upper atmosphere atomic and molecular oxygen. Previous measurements of both constituents had raised discussions between experimenters for years. Finally, he insisted on building a high-precision gas calibration system for his instruments to provide the best possible absolute densities. Because mass spectrometers traveling on fast-flying vehicles will encounter the neutral gases at high speeds, Al designed and built with his students a unique high-speed beam facility in the back room of his laboratory, in order to simulate space flights. Comet encounters and planetary entry missions were probed, and instruments perfected and calibrated. This facility was for many years a unique research tool for his group and others until the last calibration was performed with an instrument to be

flown on the space shuttle. During that time, when AES results were pouring in, the Viking spacecraft arrived on Mars, and Al's instrument on the entry science payload provided the first information on the atmospheric composition of another planet. As a team leader, he enjoyed the "Viking days" tremendously.

After his retirement in 1980, Al further perfected his small instrument to make it ultraclean and compact in size for analysis of minute amounts of gases extracted from tiny interplanetary dust particles and lunar grains. With his engineer, Dennis Schlutter, he published a series of papers in which they discussed the abundance of helium and neon isotopes. On the day of his accident he visited the lab in the morning and talked about the newest results and about his trips to Durango, Colorado, and to Germany.

Scientists often believe that unless you have changed your place of employment a number of times, you have not lived up to expectations. Al's career refutes this concept. From his freshman year until his death he spent sixty-three of sixty-seven years at the University of Minnesota (two were at Harvard on a fellowship, two in New York City on the Manhattan Project). The Twin Cities area and the university provided an environment where he felt content among his friends and colleagues to pursue his ideas in research with students and staff who often came from the same background and believed as he did in hard work and long hours in the laboratory. Al enjoyed it very much when students or postdocs became excited about their research. "When you finish your Ph.D. work you are supposed to be the world expert in your field," he said a number of times in our conversation.

When Al was asked to accept committee assignments within the university or with NASA he reluctantly did, but he never became trapped in a position that would make it difficult for him to return to his laboratory. Even during his time as department chairman (1953–65), he taught his class and entered new research fields: the Earth's upper atmosphere and space physics. Al was an individualist, not a team player who could be consumed by large research projects. He cherished personal contacts and exchange of ideas with other scientists, but he hardly ever went along for a ride in a large group. His papers always show authorship by a few individuals; on many papers he is the only author. His love for the university and for Minnesota placed no limitations on his contacts with the world outside. He loved to travel with Ardis to faraway places, and during my years in Minneapolis they both visited many countries from Europe to Australia. Visits to Mainz and Heidelberg were always high on their list. Al also knew how to relax and to have a good time and tell an interesting story or two. The

best place for him was their lake cabin in northern Minnesota where he and Ardis were gracious hosts to me and my family. They rarely used the cabin themselves. The "kids" (that is Keith Nier and Janet Marx and their families) and the many friends from the Twin Cities and Los Alamos were frequent visitors, to whom Al joyfully gave rides in his boat across Cass Lake.

The mass spectrometer was an ideal tool to solve problems in many areas of science. This instrument required a master to design and understand it and a few good people to work with it. In his life-long research career, Al never built an empire, and his experimental space in the basement of the physics building was by all means very modest. The environment he worked in and the people he communicated with on a daily basis reflected his conviction that fundamentally important research can be accomplished without big budgets and fancy facilities. "Dr. Nier" was always a welcome and frequent visitor in the machine shop. He understood the details of the experiments but was delighted when Dennis Schlutter became a wizard with the computer to integrate his experiments with modern technology.

Al Nier remained life-long a modest man with a strong loyalty to his university and foremost to his friends. His honors and citations are numerous, including his election to the National Academy of Sciences and his foreign scientific membership in the Max-Planck-Society. We were all delighted when the University of Minnesota in 1980 presented an honorary doctor of science degree to Al. He was the most remarkable person I have met in my life, who showed an undiminished love for experimental discoveries, independent of his age. In this way, Al Nier not only left us with a wealth of new information and unique instruments, but also showed us how to stay forever young.

Elected 1953

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