The Life and Accomplishments of James A. Van Allen (1914–2006)

JAMES A. Van Allen, who was one of the great pioneers of space research, died in Iowa City, Iowa, on August 9, 2006, where he lived and worked for over half a century. Best known for his discovery of intense belts of radiation encircling Earth with Explorer 1, which is the first U.S. satellite, Van Allen became the leading figure in the rapidly developing field of space research. His early studies of Earth's radiation belts, which are often called the "Van Allen Belts," developed into the field of research that is currently known as magnetospheric physics, which deals with energetic charged particles trapped in planetary magnetic fields. He also had an early interest in cosmic rays and played a leading role in the development of the field that is currently known as heliospheric physics, which deals with the extended plasma and magnetic field envelope of the Sun. Over his remarkable career, he provided dozens of instruments on spacecraft that established the principal characteristics of Earth's radiation belts and on spacecraft that made the first exploratory flybys of Venus, Mars, Jupiter, and Saturn. The analysis and publication of results from these many instruments occupied most of his professional career and continued with nearly undiminished intensity up to the time of his death at the age of 91. In addition to his extensive research, he was also a highly Respected Teacher, a Leader in formulating space policy, and an Eloquent Spokesperson on various space-related issues of national importance.

Born in the small town of Mount Pleasant, Iowa, on September 7, 1914, he showed an early interest in electrical and mechanical devices and was inspired to pursue a career in science by a high school teacher. After he graduated from high school, he went to Iowa Wesleyan College, where he majored in physics and helped prepare magnetic and seismic equipment for one of Admiral Byrd's expeditions to the Antarctic. He graduated *summa cum laude* in 1935. He then went on to earn his Ph.D. degree from the University of Iowa in 1939, with a thesis in nuclear physics. After he graduated, Van Allen received a Carnegie Research Fellowship and moved to Washington, DC, to work in the Department of Terrestrial Magnetism, Carnegie Institution, where he planned to continue his research on nuclear physics. Through an acquaintance with Scott Forbush, who was well known for his research on cosmic rays, he developed an interest in cosmic rays, geomagnetism, and solar terrestrial physics. However, before these interests could develop into a serious research effort, World War II intervened, and he soon became involved in the war effort by working under a U.S. Navy contract to develop a "proximity fuze" that would explode an antiaircraft shell as it passed near a target. In the spring of 1942, the proximity fuze work was transferred to the Johns Hopkins Applied Physics Laboratory, Silver Spring, MD. When the development phase was completed, he was commissioned as a Lieutenant in the U.S. Naval Reserve and sent into the Pacific to test the fuzes under actual combat conditions. For this service, he received four combat stars. After the war, he returned to the Applied Physics Laboratory with the intention of continuing his research on cosmic rays.

As it turned out, Van Allen's interest in cosmic rays and his experimental work on nuclear physics and proximity fuzes provided an almost ideal combination to prepare him for the next stage of his career. At that time, a crucial question in cosmic-ray research was how the cosmic-ray intensity varied with altitude. Balloon-borne measurements had already been made at altitudes up to about 40 km, and a puzzling increase in the intensity had been observed at high altitudes. In addition, the cosmic-ray intensity was known to vary with the 11-year solar cycle and to decrease following major solar flares (called a Forbush decrease). It was clear that cosmic-ray intensity measurements were needed at much higher altitude, well above Earth's atmosphere. Therefore, when an opportunity arose after the war to fly instrumentation to very high altitudes using captured V-2 rockets, Van Allen was ready. Using his nuclear physics experience and knowledge gained from the development of rugged electronics for proximity fuzes, he led the development of a Geiger tube cosmic ray detector and other various instruments for flight on V-2s and carried out a series of flights at White Sands, NM, in 1946–1948. When the supply of V-2 rockets ran out, he helped develop the Aerobee rocket to continue his high-altitude research.

In 1951, Van Allen moved from the Applied Physics Laboratory to Iowa to become Professor and Head in the Department of Physics, University of Iowa. At Iowa he continued his high-altitude research with the Aerobee rocket and pioneered the development of a low-cost balloon-borne rocket called a rockoon that could reach altitudes (80 to 100 km) comparable to those achieved by the V-2 and Aerobee rockets. Using the rockoons, he led the first latitudinal survey of the cosmic-ray intensity above Earth's atmosphere by launching a series of these rockets from U.S. Navy ships. This effort was part of the 1957–1958 International Geophysical Year (IGY), which was an international program in which he played a key role as one of the originators and organizers. One significant result of the latitudinal survey of the cosmic-ray intensity was

Digital Object Identifier 10.1109/TPS.2007.902089

the discovery of a new "soft" low-energy component that is continually present at auroral latitudes. This was the first direct detection of the low-energy particles that are currently known to be responsible for the auroral luminosity. During that time, he was also actively promoting the launch of an artificial Earth satellite as part of the IGY and was working on the design of a Geiger tube cosmic ray instrument for the Navy's Vanguard rocket program, which was designed to launch a satellite into a low Earth orbit. However, before this program could come to fruition, the Soviet Union launched the first artificial satellite, Sputnik 1, on October 4, 1957.

In the resulting frantic effort to catch up with the Soviet Union, and after a series of humiliating failures of the Vanguard rocket, Van Allen was asked to redesign his Geiger tube instrument for flight on a version of the Jupiter C rocket, which was being modified to launch a satellite under the direction of Werner von Braun at the U.S. Army's Redstone Arsenal in Huntsville, AL. The spacecraft Explorer 1, which was developed at the Jet Propulsion Laboratory in Pasadena, CA, and included Van Allen's instrument, was successfully launched on January 31, 1958. Pleased to see the expected relatively steady cosmic-ray counting rate above Earth's atmosphere, Van Allen and his colleagues were surprised to obtain data from some ground receiving stations in which there were no counts at all. Not wanting to believe that the instrument had failed, they postulated that the satellite was passing through regions with exceedingly high radiation intensities, so high that they saturated the Geiger tube, rendering it temporarily inoperative. After a launch failure with Explorer II, a similar instrument was included on Explorer III, which carried a tape recorder that allowed data to be collected for an entire orbit. These data confirmed the saturation hypothesis and showed that Earth is encircled by two very intense donut-shaped belts of energetic charged particles (currently known as primarily electrons and protons) with energies extending to millions of electron volts for electrons and hundreds of millions of electron volts for protons. The public announcement of this discovery, which was the first great scientific discovery of the space age, was made at the National Academy of Sciences in Washington, DC, on May 1, 1958.

The totally unexpected discovery of very intense and highly energetic belts of radiation encircling Earth immediately attracted worldwide attention, both in the scientific world and by the general public. Subsequent radiation detectors that were flown by Van Allen on Explorer 4 and Pioneers 1 and 3 in 1958 provided a large quantity of data that established the radial extent of the radiation belts and convincingly showed that the particles were trapped in the Earth's magnetic field, in a region that is currently referred to as the "Magnetosphere." In subsequent years, Van Allen and his colleagues proceeded to fly similar radiation detectors on the first missions to the nearby planets, including Mariners 2 and 5 to Venus, and Mariner 4 to Mars. No radiation belts were discovered at these planets, which turned out to have no appreciable magnetic fields and, therefore, no possibility of having magnetically trapped radiation. However, many other interesting results were obtained in route, including long-term observations of X-ray emissions from the Sun and the discovery of energetic electrons ejected into interplanetary space from the solar flares. During that time, Van Allen also actively promoted a mission to Jupiter, which, based on radio measurements, was believed to have a very energetic radiation belt. This effort eventually led to the Pioneer 10 and 11 flybys of Jupiter, both of which included the energetic charged-particle instruments designed by Van Allen. These flybys, indeed, confirmed that Jupiter had a very energetic radiation belt and a large extended magnetosphere. By a feat of ingenious celestial mechanics during the Pioneer 11 flyby of Jupiter, he and other NASA colleagues arranged for the spacecraft to be directed on to the first ever flyby of Saturn, which was also found to have an energetic radiation belt and a very large extended magnetosphere. However, the Pioneer 10 and 11 missions did not end at Jupiter and Saturn but continued outward toward interstellar space to explore the extended region of solar influence that is currently known as the "Heliosphere." His work on the radiation belts of Jupiter and Saturn and his quest to understand the entry of cosmic rays into the heliosphere from the interstellar space were Van Allen's main passions over the remaining 25 years of his life.

From his earliest days as a Professor, Van Allen made a practice of involving students in his research, thereby contributing to the education of an entire generation of space scientists, many of whom went on to be leaders in space research at various government, industry, and educational institutions. He was a very popular Lecturer, and for 17 years before his retirement, he taught a large undergraduate course in astronomy. Even today, more than 20 years after he last taught this course, it is not uncommon to meet people from all walks of life who say that one of their most rewarding experiences at the University of Iowa was taking Van Allen's Astronomy course. During the 34 years of teaching at the University of Iowa, he supervised 48 M.S. theses and 34 Ph.D. dissertations.

Throughout his career, Van Allen's impact on space science in the United States and the world has been enormous. His leadership in the explorations of Earth's magnetosphere and of the solar system shaped the early direction of NASA's scientific program, and some of the missions that he promoted are still breaking new ground in the solar system (e.g., Voyagers 1 and 2). His physical intuition and grasp of basic physics provided the underpinnings for the correct understanding and interpretation of the observations, the development of quantitative models, and the insight on what is needed to be measured next to extend the understanding of the field. His contributions to the scientific literature are nothing short of phenomenal, including some 270 papers from 1937 to 2006, three books, Editor of two others, plus innumerable lectures at national and international meetings. For his research and teaching, he received many awards, including membership in the National Academy of Sciences, the National Medal of Science from President Ronald Reagan in 1987, and the Crafoord Prize from the King of Sweden in 1989, just to mention a few.

In addition to his scientific accomplishments, Van Allen was a strong proponent of automated robotic spacecraft and a consistent critic of human spaceflight. He argued that most space research can be accomplished by robotic spacecraft and that human crews are of very limited utility considering their very high cost. He was particularly critical of the Space Shuttle and the International Space Station, starting from the inception of these programs in the 1970s and the mid-1980s and continuing up to the time of his death. Given the great cost and very limited scientific achievements of these two programs, his early views on the utility of human space flight appear to be well justified.

In summary, Van Allen's contributions to space science and to human knowledge have been enormous and have had a strong and lasting impact. He was not only a gifted Researcher and Teacher but also a very kind and caring person. He will be greatly missed by all who knew and worked with him.

DONALD A. GURNETT
James A. Van Allen/Roy J. Carver Professor of Physics
Department of Physics and Astronomy
University of Iowa
Iowa City, IA 52242 USA

STAMATIOS M. KRIMIGIS
Emeritus Head, Space Department
Applied Physics Laboratory
Johns Hopkins University
Laurel, MD 20723 USA