JAMES ALFRED VAN ALLEN
FROM HIGH SCHOOL TO THE BEGINNING OF THE SPACE ERA
A BIOGRAPHICAL SKETCH

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James Van Allen was instrumental in establishing the field of magnetospheric research in space. This paper provides a glimpse of his life, from the time he was a high school student until the launch of the first United States Earth satellite. The more complete story of the development and flight of the first University of Iowa satellite instruments is outlined in the companion paper *The First Explorer Satellites*. Carl McIlwain will take over this tale from that point, including the discovery and early delineation of the radiation belts.

This paper is an extraction from much more voluminous material being prepared for publication as a full-length book. That book will describe the history of the Iowa Physics Department's space-related work during the period 1951 through 1960. Publication of the book is planned in time for the celebration of the Explorer I launch in January 2008.

Material for the book and this paper was derived from many published papers and unpublished sources. Van Allen's assorted autobiographical papers, especially, were drawn upon heavily. His paper in the AGU monograph series on the Discovery of the Magnetosphere,[1] much of which was repeated in the Guide to the James A. Van Allen Archives,[2] was especially helpful. Many of the sources are cited in the notes at the end of this paper, and others will be acknowledged in the book. The contributions of all of the sources are gratefully acknowledged.

The Early Years

James Alfred Van Allen was born on 7 September 1914 on a small farm near Mount Pleasant, Iowa, the second of four sons of Alfred Morris and Alma Olney Van Allen. He grew up in the small town of Mount Pleasant, located forty-five miles due south of Iowa City.

Van Allen credits C. A. Cottrell, a science instructor in his high school, with stimulating his initial interest in science. He developed parallel interests in wood and metal crafts and did well in other subjects, becoming valedictorian of his Mount Pleasant High School class upon his graduation in June 1931.

His slightly flat feet probably preserved Van Allen for the role that he was to play in developing the field of space science. With a strong interest in things nautical (which he retained throughout his life), he took the entrance examinations for entry into the U.S. Naval Academy while in high school. With outstanding grades, and with the backing of his local Congressman, he applied for admission. All went well initially, but when he appeared for his physical examination, he was rejected for three reasons. He had flat feet, his eyesight was somewhat deficient, and he didn't know how to swim.

Thus, he was forced to pursue a different path. Immediately following high school, Van Allen went to Iowa Wesleyan College there in Mount Pleasant, majoring in physics and graduating *summa cum laude* in a class of 38 in June 1935. It was at Iowa Wesleyan during the summer of 1932, after completing his freshman year, that Van Allen was introduced to geophysics research under the tutelage of Physics

Professor Thomas C. Poulter. Van Allen retains to this day his great admiration for this early mentor. He stated in one of his autobiographical sketches, “Poulter, [was] one of the most inspiring and creative experimentalists that I have ever known before or since that time…” Poulter employed him as a summer assistant, “at 35 cents an hour, payable occasionally.” [3]

Poulter had been chosen by Admiral Richard E. Byrd as his chief scientist for the 1933-1935 Second Byrd Antarctic Expedition. He had the task of planning and conducting geophysical investigations during that expedition. Van Allen assisted Poulter in those preparations; his contributions included the development of a number of instruments, including a simple seismograph and a tilt-meter for recording the shifting of glacial surfaces.

Van Allen was entrusted with the checkout of an extra sensitive field magnetometer on loan from the Department of Terrestrial Magnetism (DTM) of the Carnegie Institution of Washington, DC. In learning how to use the magnetometer and its associated theodolite, he made a magnetic field survey of Henry County, Iowa, which was included in the 1932 national grid published by the Department of Terrestrial Magnetism. Reflecting later on this magnetometer, he referred to it as, “…the most beautiful instrument that I have ever used.” In the course of his work with Poulter, Van Allen learned machine shop practice, glass blowing, welding and brazing, vacuum techniques and, of greatest importance, the essential elements of original experimental research.

Poulter invited Van Allen to accompany him as a member of the Antarctic Expedition, but his parents vetoed the idea. He had to be content with listening avidly to the short-wave radio reports from Little America to follow the expedition’s progress. He, with the rest of the world, was electrified by Poulter’s heroic rescue of Admiral Byrd from his lonely vigil at South Pole Station in August 1934.[4] Poulter and Byrd were honored by a public parade in Mount Pleasant the next summer, and Admiral Byrd delivered the chief commencement address at Van Allen’s graduation exercises.

It was only natural that Van Allen would go to his “family” university, the State University of Iowa, for his graduate work in physics. The physics faculty at the time numbered five, George W. Stewart (department head from 1909), John A. Eldridge, Edward P. T. Tyndall, Claude J. Lapp, and Alexander Ellett. Van Allen’s master’s thesis in solid-state physics, with Tyndall as his advisor, was entitled *A Sensitive Apparatus for Determining Young’s Modulus at Small Tensional Strains*. He received his M.S. degree at the end of his first year there, in 1936. For his Ph.D. research, he worked with Professor Ellett, who was switching his primary focus at that time from atomic beams to experimental nuclear physics. As part of his work, Van Allen, with Robert Huntoon and others, built a highly improvised Cockroft-Walton high-voltage power supply and accelerator. After much hard work and diligent coaxing of the cantankerous machine, he was eventually able to make a pair of successful runs, resulting in his dissertation *Absolute Cross-Section for the Nuclear Disintegration* $H^2 + H^2 > H^3 + H^1$ *and Its Dependence on Bombarding Energy [50 to 380 keV]*. He received his Ph.D. degree in June 1939.

The Carnegie Institution, the Applied Physics Laboratory, and World War II

Following graduation, Van Allen went to work as a Carnegie Research Fellow at the Department of Terrestrial Magnetism. During 1939-1940, Van Allen worked there in Merle A. Tuve’s nuclear physics laboratory. His pre-war published papers reflect the character of his work there, addressing such topics as nuclear reaction cross-sections and angular distributions.

Van Allen never lost his interest in geophysics, and found at the DTM fertile ground for a flowering of that interest. The department’s traditional work was on geomagnetism, cosmic rays, auroral physics, and ionospheric physics. The DTM association placed him in direct contact with a wide spectrum of leading geophysicists of the day, including staff members Scott Forbush, Harry Vestine, John Fleming, Alvin McNish, and Bill Rooney. In addition, European geophysicists Sydney Chapman and Julius Bartels were occasional visitors there while they were preparing their seminal two-volume work

Geomagnetism. Many of those individuals became Van Allen's close associates and played key roles in his later professional life.

By late 1939, the war in Europe was under way. Recognizing the need for strengthening the military capability, DTM director Tuve, after extensive inquiry and study, converted much of the institution's effort to the practical development of the embryonic proximity fuse to increase the effectiveness of naval anti-aircraft fire. In the summer of 1940 Van Allen asked to become a part of that effort, and was appointed to a staff position in the National Defense Research Council of Vannevar Bush's newly created Office of Scientific Research and Development. His initial work was on a photoelectric proximity fuse, but he soon shifted to work on the radio version. Both approaches were shown to be workable, but the radio approach was ultimately chosen for deployment, and its further development progressed rapidly.[5]

Before long, the radio fuse development outgrew the capacity of the DTM. Tuve negotiated an arrangement with Johns Hopkins University for that organization to take over contractual oversight of the project for the Navy, and the Applied Physics Laboratory (APL) was established for that purpose. It set up shop in a rented Chevrolet garage in downtown Silver Spring, on the north side of Georgia Avenue two doors west of Colesville Road. Tuve, Van Allen, and other members of his group transferred to the APL in April 1942 as part of its initial cadre.

Van Allen's principal initial focus in the proximity fuse work was in developing rugged miniature vacuum tubes that could withstand the shock and acceleration of gun-fired projectiles. Miniature tubes previously developed by the Raytheon and Sylvania Companies served as the starting point. Working primarily with the Raytheon Company, by a largely trial and error process, tubes that met the requirements were finally developed. Millions of these vacuum tubes were produced for wartime use, and after the War, they became a staple component of rocket-borne research instruments until they were eventually replaced by transistors.

In response to the need for knowledgeable people to assist in introducing the evolving proximity fuses into use by the Navy at sea, Tuve again enlisted Van Allen's help. In November 1942, he and two others were commissioned directly from their posts at APL into the U.S. Naval Reserve as lieutenants (junior grade) to fill this role. They took the first of the highly secret radio proximity fuses to the South Pacific for this purpose. Van Allen's personal role was to instruct gunnery officers in the shipboard use of the new devices, to observe their performance and report on their effectiveness, and somewhat later to set up distribution facilities at ammunition depots in Noumea, New Caledonia, Espíritu Santo, Tulagi, Guadalcanal, Manus Island, and on a number of ammunition barges.

The V-2 and Aerobee Programs at the Applied Physics Laboratory

At the conclusion of the war, Van Allen had a number of discussions with Tuve about his interest in resuming peacetime research. They led to Van Allen's return to the APL in late 1945. Upon his arrival, he organized the High Altitude Research Group with a talented group of researchers including Lawrence W. Fraser, Clyde Holliday, John Hopfield, Robert Peterson, Howard Tatel, and several others. He supervised this group from its formation in 1946 until his departure from APL in late 1950.

Not long after his return to APL, he was told by staff member Henry H. Porter about the Army Ordnance Department's plans for using captured German V-2 rockets for high altitude research. On 16 January 1946, he met with a group of scientists at the Naval Research Laboratory (NRL). This meeting was an outgrowth of ongoing internal NRL discussions to decide upon a major post-war research topic. Acting upon the suggestion of NRL's Milton W. Rosen, Ernest H. Krause's Communications Security Section decided to apply its wartime experience with missiles and communications to the study of the upper atmosphere. This was approved by NRL's director in December 1945, and the section's name was changed to the Rocket Sonde Research Section.

Interestingly, this group's initial period of self-education in the needs, techniques, and nuances of upper atmospheric research included discussions about the use of artificial Earth satellites. Homer

Newell gave several lectures dealing with that possibility. However, that objective was set aside then because of its expected high cost and the long time required to reach it. The NRL group concluded that their initial efforts needed to be concentrated on more immediate results.

At APL, Van Allen's group soon developed plans for a comprehensive program to measure the primary cosmic rays, solar ultraviolet spectrum, geomagnetic field in the ionosphere, and the altitude distribution of ozone in the upper atmosphere. Thus, both APL and NRL concurrently formulated somewhat similar programs. They quickly became both collaborators and competitors.

In addition to the areas just mentioned, magnetic field measurements well above the Earth's surface were of considerable interest. The APL group maintained a close collaboration with Ernest H. Vestine at the Department of Terrestrial Magnetism and with Allen Maxwell at the Naval Ordnance Laboratory to develop flux-gate magnetometers to make these measurements. Additionally, there was an interest in optical and infrared imaging from the high atmosphere for the study of atmospheric conditions and patterns, and Clyde T. Holliday of the APL group undertook the development of recoverable cameras for that purpose.

One of the important outcomes of the January 1946 meeting between the APL and NRL staffs was the formation of an unofficial group of scientists that initially called itself the "V-2 Rocket Panel." This name was soon changed to the "V-2 Upper Atmosphere Panel." It began its work immediately, holding its first formal meeting on 27 January 1946 with Krause as its energetic and effective first chairman. The group's initial role was to help plan for the effective utilization of the V-2 flights for research.[6] Because of Van Allen's strong interest in high-altitude research, his experience with rockets, and his familiarity with very rugged miniature vacuum tubes and circuitry, he was included as a valued charter member of that Panel.

When Krause left for industry in December 1947, Van Allen was elected to chair the group. He continued as its chairman throughout the rest of its lifetime (through additional name changes to the "V-2 Upper Atmosphere Research Panel" in September 1946, the "Upper Atmosphere Rocket Research Panel" in March 1948, and the "Rocket and Satellite Research Panel in April 1957"). When the National Aeronautics and Space Administration (NASA) was formed on 1 October 1958, some of the Panel's functions were taken over by that new agency, and the Space Science Board of the National Academy of Sciences assumed others. Nevertheless, the Panel continued for several additional years as sponsor of a series of colloquia. It finally simply quit operating in 1960, and turned its files over to the Smithsonian Institution's National Air and Space Museum. A full set of the minutes and other records of the group was retained by Van Allen, and is now available as a part of the James A. Van Allen Special Collection at the University of Iowa Library Archives.

This group is emphasized here because of its tremendous importance in overseeing the selection of experiments for rocket and satellite flights from 1946 until after NASA was formed in 1958, and in recognition of Van Allen's pivotal role in the conduct of its work.

The program for American scientists to provide instruments for the V-2 program was initially envisioned as a very short program of only five-month's duration, encompassing about 25 launches. It was later extended, in both duration and number of launches, to encompass the flights of a substantial number of instruments prepared by Van Allen and many others. At the same time the flights were being made, the scientists recognized that they would need a launch vehicle to continue their high-altitude scientific research after the V-2 program ended. The Upper Atmosphere Research Panel served as the focal point for efforts to meet that need. Merle Tuve and Henry Porter at APL suggested that a follow-up development take place, and Van Allen, from his position as head of the APL High Altitude Research Group, undertook a survey of U.S. efforts that might result in suitable rockets for high-altitude research. He was greatly assisted in this study by Rolf Sabersky of what had by then become the Aerojet Engineering Corporation, a company spawned by the west coast Jet Propulsion Laboratory.

Concurrently, a similar interest was unfolding at NRL. These two endeavors led to a rocket development proposal from Aerojet, followed by contracts in early 1947 with Aerojet and the Douglas Aircraft Company. Van Allen provided technical supervision, serving as the agent of the Navy's Bureau of Ordinance that provided the financial support for the work. The outcome of this contract was the Aerobee sounding rocket.

The Aerobee achieved a remarkable record in U.S. suborbital high-altitude research.[7] Its initial test firing occurred on 25 September 1947, followed quickly by the first successful launch of an instrumented payload on 24 November 1947. By 1951, thirty Aerobees had been launched, and during the ten-year period from September 1947 to September 1957, 165 Aerobees were launched from the Army's White Sands Proving Ground, the Air Force's nearby Holloman Air Development Center, Fort Churchill in Manitoba, Canada, and from shipboard at sea. As of 17 January 1985, a total of 1037 Aerobees had been fired for a wide variety of investigations in atmospheric physics, cosmic rays, geomagnetism, astronomy, and other fields. Most of the successful Aerobee research flights achieved peak altitudes between 40 and 65 miles, depending on payload weight and other factors. The record height of over 91 miles was achieved by U.S. Air Force flight number 56 on 15 June 1955.

Returning to the early research program in Van Allen's High Altitude Research Group; with some urging by Harry Vestine, a student of Sydney Chapman at Oxford University, Van Allen's group undertook a search for the equatorial electrojet in 1947. This phenomenon had been inferred by Chapman and Julius Bartels at Oxford from ground-based magnetometer records. A three-axis fluxgate magnetometer of a type in use at the Naval Ordnance Laboratory looked promising for this work, and Van Allen, S. Fred Singer, and Lawrence Fraser adapted it for flight in the Aerobee rockets. The first flight trial of this instrument was made at the White Sands Proving Ground in New Mexico on 13 April 1948, where the rocket soared to a height of 70 miles. The magnetometer obtained good measurements throughout the flight, thus validating the instrument design, although, of course, the electrojet was not observable that far north.

With this successful test, a major field expedition was undertaken the following year. It culminated in March 1949 in the launch of three Aerobees near the magnetic equator off the coast of Peru from the deck of the *USS Norton Sound*. This expedition achieved a number of important firsts. It provided the first U.S. flights of high-altitude sounding rockets at any location other than White Sands. It was the first launch from shipboard, thus paving the way for numerous ship-based sounding rocket and rockoon flights over the next decade. On one of the early flights, the magnetometer yielded the signature of at least a partial penetration of the electrojet in the altitude range 58 to 65 miles.[8]

Van Allen's tenure at the Applied Physics Laboratory from 1946 to 1951 covered a highly productive period.[9] The work of that laboratory was an important component of a larger national effort in high altitude research which, over the years, made substantial advances in understanding atmospheric structure, ionospheric physics, cosmic rays, geomagnetism, the ultraviolet and x-ray spectra of the sun, and in high altitude photography of cloud cover and the Earth's surface. This extensive effort included the development of rockets, instruments, methodologies, and organizational structures for high altitude research that served as the foundation for the movement into space during the decade of the 1950's.

Fundamental changes began to occur within the Applied Physics Laboratory in 1950 when R. C. Gibson replaced Merle Tuve as its director. Among other things, Van Allen was asked to pick up supervision of the residual proximity fuse work in addition to his group's work in high altitude research. He accepted this task, but interpreted it as foreshadowing a decrease in emphasis on high altitude research, and a shifting away from the freewheeling spirit that had marked their work up to that time. He began to ponder his future prospects for productive research in his chosen field of interest within that organization.

By this point in his career, Van Allen had established an international reputation in upper-atmospheric physics research. His background became especially important as the space program slowly began to take shape, and Van Allen's name appeared with increasing frequency during its early planning. It is notable that, throughout his period at APL, Van Allen was able to combine responsibility for a broad span of supervisory and managerial duties with his personal research, a valuable and remarkably rare ability that he was to continue throughout his professional career.

The State University of Iowa

By a fortuitous coincidence, at about the same time that Van Allen was pondering his future at APL, a vacancy occurred at his *alma mater,* the State University of Iowa's Department of Physics. Louis A. Turner had resigned as department head, a post that he had held for the previous four years. Professor Tyndall, Van Allen's earlier research mentor, called Van Allen to inform him that he had suggested him for the position. Van Allen was excited by the prospect, expressed his interest, and made a trip to Iowa to explore it. After some time had passed, he was offered the position as department head with the rank of full professor. After an additional half-year to clean up his work at APL, he, with Abigail (Abbie), his wife of five years, and their two daughters made the move. The family arrived in Iowa City in their car, pulling a trailer with most of their possessions, on a very cold first day of January 1951. They were put up initially in one of the corrugated metal barracks that were built after World War II primarily to house returning veterans and their families.

Initiating the Cosmic Ray Research Program with Balloons

Van Allen's primary research aspiration upon arriving at Iowa was to extend earlier observations of primary cosmic rays to above the substantial atmosphere, and to a wider range in latitude. His overriding aspiration was to establish capabilities for this type of research in a teaching university's academic environment.

Upon his arrival at the University, he found no cosmic ray research budget. There was, however, an active nuclear physics research group. Among other things, they had an excellent machine shop with two skilled instrument makers and a modest electronics laboratory for instrument development. These facilities became important components of his new cosmic ray group.

Van Allen obtained a modest initial grant from the private Research Corporation that helped him get started. Soon thereafter, he prepared a proposal to the U.S. Office of Naval Research (ONR) for measuring the primary cosmic ray intensity at high altitudes by a low-budget approach using a balloon/rocket combination to reach above the appreciable atmosphere. The proposal was funded, and this was the beginning of a tremendously productive relationship, with ONR financial support for portions of Van Allen's work continuing unbroken through the next thirty-eight years.

One of Van Allen's early actions after his arrival was to hire Melvin (Mel) B. Gottlieb, a recent University of Chicago graduate. Van Allen's first graduate student, Leslie (Les) H. Meredith, followed soon by Robert (Bob) A. Ellis, Jr. developed, tested, and flew the first Iowa balloon-borne instruments. This balloon program's objective was to initiate a program of cosmic ray research at the University, and in the process, to gain experience with Geiger Müller (GM or simply Geiger) counters and their associated electronic circuits, and with balloon flying and telemetering techniques. Meredith's scientific objective was to measure the cosmic ray vertical intensity as a function of altitude, with a directional telescope using thin-walled Geiger counters.[10] He launched a series of seven balloon flights from the Iowa City airport between June 1951 and February 1952.

Balloons were used at Iowa for cosmic ray research throughout the decade of the 1950's. After the very earliest flights with the clusters of small balloons, Frank McDonald and Kinsey Anderson, when they joined the Iowa staff from Minnesota, introduced the use of larger balloons. From that point, Van Allen concentrated increasingly on the rockoon flights and, later, the satellites and space probes.

Inventing the Rockoon

The objective that was the primary focus of the initial Office of Naval Research grant was to extend cosmic ray observations to altitudes higher than could be reached by balloons. For this purpose, Van Allen and his staff developed the *rockoon*.

The rockoon is a balloon/rocket combination that made it possible to reach high altitudes with small but useful payloads at very low cost. The idea was first suggested to Van Allen by Lee Lewis of the U.S. Navy (USN) during the Aerobee-firing cruise of the *USS Norton Sound* in March 1949.[11] The concept was further developed in discussions during that cruise by the two of them, along with George Halverson of the Navy and S. Fred Singer of the University of Maryland. The basic concept was that small, inexpensive military-surplus rockets could be lifted by balloons to an altitude of the order of eleven miles before firing. When fired, the rockets would already be above the densest portion of the atmosphere. By thus avoiding the dominating influence of aerodynamic drag in the lower atmosphere, a much higher altitude could be achieved than if the rocket were fired from the ground. These rockoons eventually made it possible to carry payloads weighing 40 pounds to peak altitudes greater than 60 miles for an expenditure for the rocket and balloon of less than $1800 for each flight. This compared with about $25,000 for each ground-launched Aerobee and $450,000 for each Viking rocket needed to reach comparable altitudes.

Shipboard launching made the concept attractive and feasible for several reasons: (1) a ship can steam downwind while the balloon is being inflated to minimize the relative wind seen by the tethered balloon-rocket combination, (2) ships at sea can avoid populated areas and the possibility of damage by returning rockets fired at variable and largely uncontrollable positions and angles, and (3) a wide geographic area can be covered from a single field installation.

The general techniques and the logistics of launching rockets from shipboard had already been worked out by a succession of five Aerobee and one Viking rocket launches during 1949 and 1950. Launching the rockoons from shipboard was a simple extrapolation of those techniques. The cost of the rockoon field operations could be kept low because it was not necessary to commit and operate the ships for this exclusive purpose. The scientific endeavors represented add-on tasks for vessels that were already sailing into the regions of scientific interest for other purposes.

The basic rockoon concept was reduced to practical form at SUI during late 1951 and 1952.[12, 13, 14] After initial testing of system components at the U.S. Naval Ordnance Missile Test Facility at the White Sands Missile Range, New Mexico during June and July 1952, the first full scientific field expedition to use the technique was undertaken on the U.S. Coast Guard Cutter *Eastwind* during August and September 1952. Expedition participants were Van Allen, Meredith, and technician Lee Blodgett from Iowa, with Lt. Malcolm S. Jones representing the Office of Naval Research. The icebreaker sailed up the Davis Strait between Canada and Greenland and beyond, primarily on a mission to resupply the weather station at Alert Base on the northwestern shore of Ellesmere Island.

The Iowa group, joining the ship at Thule, Greenland, set up a laboratory in a room below decks, while the balloon support team arranged their equipment for inflating and launching the balloons on the ship's helicopter deck.[15] The ship departed Thule on 29 July 1952. During that voyage, Van Allen made his closest approach to the North Pole, when the ship passed within 508 miles. This, by the way, established a new record for the closest approach to the North Pole by any ship under its own power.

Upon their return toward Thule, in the mouth of Murchison Sound near the north end of Baffin Bay, the scientists launched their first rockoon on 20 August 1952. The instruments for this first series were of two types. One, prepared by Les Meredith as a part of the work for his Ph.D. thesis, contained a single Geiger-Müller counter to measure the absolute intensity of cosmic radiation above the effective atmosphere as a function of height and geomagnetic latitude. The second type of instrument, prepared by Bob Ellis for his Ph.D. thesis, contained an ionization chamber to measure total cosmic ray ionization.

Seven flights were attempted, and the balloons performed properly in all seven cases. However, the first two rockets, both of which carried Meredith's instruments, failed to ignite because of failure of pressure switches due to low temperatures. Cans of fruit juice were added to the firing gondolas to keep the switches warmer during the balloon ascent. The next rockoon flight, on 28 August 1952 (SUI flight number 3), was the world's first fully successful rockoon flight. The rocket fired at an altitude of 38,000 feet fifty-five minutes after release of the ensemble from shipboard. It reached an estimated summit altitude of about 200,000 feet or nearly 38 miles.

The remaining four flights were also ballistically successful, with the best performance being a flight to over 55 miles height. Of the total of five ballistically successful flights, four provided good flight data in the region around 88° north geomagnetic latitude. They lofted two each of Meredith and Ellis' instruments.

Van Allen presented a paper in the fall of 1952 that gave preliminary results from Meredith's two flights.[16] This paper provided a summary of previously existing knowledge of the cosmic ray environment, plus the newly derived information about the low-rigidity end of the primary cosmic ray spectrum.

After the initial development and field proof of the rockoon technique, Van Allen was eager to put it to further use. Follow-on expeditions were mounted during 1953 (led by Melvin Gottlieb), 1954 and 1955 (led by Frank McDonald), and 1957 (two expeditions led by Van Allen), to exploit this capability. Further stepwise improvements were incorporated as experience and the state of the technology evolved. Combined with the ongoing balloon work, the research program produced important scientific results, sharpened the skills of the students and staff, and developed a high-altitude research capability that was second to none.

The most significant single new finding from the 1952 through 1955 rockoon expeditions was the initial discovery, delineation, and early characterization of the so-called "auroral soft radiation." It was first observed during the 1953 expedition by one of Meredith's Geiger counters. The initial hypothesis was that it had registered primary auroral electrons having energies in the neighborhood of 1 MeV.[17] It was understood that the observed energy spectrum was low enough that most of the particles could not be coming directly from distant sources such as the sun.

This discovery prompted the development of follow-on instruments for more discriminating measurements. On the 1954 and 1955 expeditions, the combination of multiple GM counters with and without additional shielding, paired with a very thinly shielded Sodium Iodide scintillation detector, helped to characterize the radiation. The measurements from those flights showed that, although the GM counters were not seeing the auroral electrons directly, they were seeing primarily X-rays produced by the electrons as they were arrested by collisions in the nose cone and upper atmosphere (*bremsstrahlung*). It was deduced that the auroral primary radiation consisted primarily of electrons with energies in the range of 10-100 keV.

During the 1952 through 1955 expeditions, twenty-two University of Iowa and two Naval Research Laboratory flights were made with instruments technically capable of detecting the auroral soft radiation. Ten of the SUI flights were flown in a suitable location for detecting it, and by early 1956 a clear pattern was emerging.[18] They are best summarized in a 1957 paper by Van Allen.[19] The data showed a strong peak in the measured relative intensity at about 67° north geomagnetic latitude, the same latitude where the peak occurrence of the visible auroras is normally seen.

This finding was unexpected and caused considerable excitement. It constituted the earliest *in situ* detection and measurement of the primary auroral radiation presence, composition, and intensity. Additional rockoon observations by Van Allen during 1957 further defined the characteristics of this phenomenon.[20]

Had we known more about magnetospheric physics in 1953-1957, it might have been possible to deduce that some of the X-rays were produced by charged particles in the cusps of what came to be known as the Outer Van Allen Radiation Belt.

Planning the IGY

Van Allen played an important role in planning for the International Geophysical Year of July 1957 through December 1958. It began at an informal and largely spontaneous dinner party at his home, on 5 April 1950. James and Abigail Van Allen's guests at that dinner party were Lloyd V. Berkner, Sidney Chapman, J. Wally Joyce, S. Fred Singer, and E. Harry Vestine. The dinner featured, in addition to the meal prepared by Abigail, a wide-ranging conversation focused substantially on geomagnetism and ionospheric physics. During continuing conversation after the dinner, Lloyd Berkner suggested to Sydney Chapman that it might be about time for a Third International Polar Year. By the end of the evening, the group, with Chapman, Berkner, and Joyce taking the lead, had mapped out a strategy for proceeding with the endeavor.

Planning for this program moved forward very rapidly, as has been widely reported.[21, 22, 23, 24, 25] In October 1952 its scope expanded to include synoptic observations of geophysical phenomena over the whole surface of the Earth, and its name changed from the International Polar Year to the International Geophysical Year. Overall planning from that point was led by the Comité Speciale de l'Année Géophysique Internationale (CSAGI), initially chaired by Sidney Chapman, with Lloyd Berkner serving as its vice-chairman and Marcel Nicolet as its secretary general. The Russian Vladimir Beloussov and the Frenchman Jean Coulomb also served as initial CSAGI members. The United States National Academy of Sciences set up a U.S. National Committee for the IGY under Joseph Kaplan's chairmanship to lead this country's planning for the IGY

With time, as the technology of rocketry and instrumentation evolved, the CSAGI added the objective of launching Earth-circling instrumented satellites to the stated IGY goals. This led to President Eisenhower's announcement in July 1955 of the U.S. intent to launch an artificial Earth satellite as a part of the U.S. contribution to the IGY. After this announcement, the U.S. National Committee established a Technical Panel for the Earth Satellite Program (TPESP) chaired by Richard W. Porter. In turn, that panel established two Working Groups, a Working Group on Internal Instrumentation (WGII), chaired by Van Allen, and a Working Group on External Instrumentation (WGEI), chaired by JPL Director William H. Pickering.

As these events unfolded, it looked increasingly like Van Allen's University of Iowa group would be playing a major role, in terms of balloon-, rocket-, and rockoon-launched instruments, and in developing one of the first U.S. satellite instrument packages. Van Allen had been dreaming of conducting a cosmic ray experiment from Earth orbit since he became aware, in 1954, of developments by the Wernher von Braun-headed Army Ballistic Missile Agency at Huntsville, Alabama. This prompted him to prepare a preliminary outline for a cosmic ray satellite experiment in November 1954.[26] On 25 September 1955, following President Eisenhower's announcement, he submitted a more completely developed *Proposal for Cosmic Ray Observations in Earth Satellites* to the U.S. National Committee.[27]

By this time, many potential experimenters had been busily developing their ideas for scientific investigations via satellite instruments. The Upper Atmosphere Rocket Research Panel, still under Van Allen's chairmanship, at its meeting on 27 October 1955, organized a meeting to explore the entire range of prospective scientific investigations in space. This occurred in the form of the tenth annual meeting of the UARRP at Ann Arbor, Michigan in late-January 1956. Thirty-three papers outlining the wide range of active and passive experiments then envisioned were presented.[28] One of those proposals was Van Allen's, in the form of an expansion of his September 1955 proposal.[29] The general objective was stated in that paper as "to provide a unique study of cosmic rays on a geographical and temporal basis," with specific objectives for "determination of the effective geomagnetic field; the magnetic rigidity spectrum of the primary radiation; time variations of intensity and their correlations with solar and magnetic observations and with the observed intensity of secondaries observed in ground stations; and cosmic-ray albedo of the atmosphere."

The Ann Arbor meeting was a relatively small one by later standards. It was suffused by a strong spirit of common purpose and cooperation in setting the stage for meaningful scientific research via the eagerly anticipated Earth satellites. This spirit continued throughout the entire period of the IGY.

The SUI Program for the IGY

Soon after the Ann Arbor meeting, Van Allen held one of his occasional sessions with his graduate students. At that gathering, he outlined a set of very ambitious scientific undertakings that might be undertaken at the University as a part of the IGY program. By Carl McIlwain's and Larry Cahill's recollections, his list of possible projects included six cosmic ray, two auroral soft radiation, and two magnetic field studies using a variety of balloons, ground-launched rockets, rockoons, and satellites.[30, 31] From this discussion emerged specific plans for an IGY program of balloon flights, ground-launched Nike-Cajun sounding rockets, and two shipboard rockoon expeditions, in addition to the cosmic ray satellite experiment, for which I was just beginning to develop the instrument.

Carl, nearing receipt of his Master's degree, undertook the further study of the auroral soft radiation using ground-launched rockets at Fort Churchill, Canada. Larry Cahill was also soon to receive his Master's degree based on his development and first balloon test of a single-coil nuclear free-precession magnetometer. For his IGY project, he undertook a field study of the equatorial electrojet and polar ionospheric electrical currents by the use of his new magnetometer, as adapted for flight on Loki-based rockoons. Ernie Ray, nearing receipt of his Ph.D. degree, continued his work on theoretical cosmic ray physics to provide important underpinnings for the rest of us. Joe Kasper, also working on his Ph.D., added his substantial contributions to the theoretical and mathematical work.

Concurrently, post-doctoral associate Frank McDonald, working with student Bill Webber, planned and conducted large-balloon flights with relatively elaborate sets of apparatus to study the charge and energy spectrum of the primary cosmic rays. Associate Kinsey Anderson also led a number of large balloon projects to study cosmic rays and the auroral soft radiation.

It should be noted that Van Allen, in addition to being department head and carrying a normal teaching load, made the programmatic and financial arrangements in Washington for major portions of the program, served as faculty advisor for his graduate students, and took direct charge of a battery of IGY rockoon flights on two expeditions ranging from northern Greenland to the Antarctic's Ross Sea.

The 1957 Arctic and Pacific Rockoon Expeditions

The culmination of the IGY rockoon program at Iowa consisted of an end-to-end pair of expeditions undertaken by Van Allen, Cahill, and coworkers in 1957. The first of these expeditions, on the Landing Ship Dock *USS Plymouth Rock*, was to the northern auroral zone with eighteen Loki rockoons. There followed an expedition to the equator and onward to the southern auroral zone on the icebreaker *Glacier* with thirty-six rockoons. These expeditions employed Loki Phase II rockets as replacements for the larger Deacons used during the earlier rockoon expeditions. Their use had been tested during the flights of Carl McIlwain's instruments during the 1955 arctic rockoon expedition, and they were available through the military for about $300 each.

Members of the 1957 northward expedition were Van Allen, Cahill, undergraduate students Donald Simanek (assisting Van Allen) and Gary Strine (assisting Cahill). The primary mission of the *USS Plymouth Rock*, a U.S. Navy Landing Ship Dock (LSD-29), was to resupply the Thule base in northern Greenland. The rockoon support was an add-on mission. The ship, with the scientists and their equipment aboard, departed Norfolk, Virginia on 1 August 1957. The explorers returned from the northward expedition on 20 August, and had time for additional work on their instruments before departing for the Pacific. This second expedition, on which Van Allen and Cahill were the sole

University of Iowa participants, departed Boston southbound on 23 September 1957 on the icebreaker *Glacier*, not to return to land until they put in at Port Lyttleton, New Zealand on 10 November.

The pair of expeditions featured the launch of two types of instrument. The primary purposes of Van Allen's combined northward and southward expeditions were to conduct a survey of cosmic ray intensity over a wide range of latitudes, to further investigate the anomalous auroral radiation detected on previous expeditions in the northern hemisphere, and to search for a complementary anomalous radiation in the southern hemisphere. His instrument packages employed either one or two GM counters. An unshielded counter was carried on all flights, and some flights carried a second counter with added shielding. On the northern expedition, he made 13 launches, of which 11 produced useful data at balloon altitude.[32] Seven of those also produced data from the rocket phase, and six of those detected the auroral bremsstrahlung.[33]

On the southern expedition, Van Allen fired his first rockoon off the U.S. coast as they neared the Bahama Islands. After passing through the Panama Canal, the ship put in at Balboa to load supplies, including additional helium for the balloons. While helping to load the helium bottles, Van Allen received a bad gash in his leg.

Soon after departing Balboa toward the neighborhood of Christmas Island, Van Allen got off a second flight on 4 October just west of Panama. But on 7 October, his injured leg became severely infected, and he was largely confined to his bunk with a high fever while being treated by the ship's doctor. On 13 October, as they approached Christmas Island due south of Hawaii, Cahill launched one of Van Allen's cosmic ray rockoons. Van Allen was able to resume a normal schedule on 17 October, and the following day he launched another of his rockoons due north of Christmas Island.

Thereafter, as the ship proceeded southward, Van Allen launched a rockoon every second, third, or fourth day. Throughout this Pacific expedition, fifteen of Van Allen's flights produced good data during the balloon portion of the flights. The rocket portions of the flights were, however, greatly disappointing. Although there were only two failures of the rockets to fire, only four of the remaining thirteen flights produced good data during the rocket portions of the flights.

In spite of these problems, Van Allen's fifteen good balloon flights, added to the thirteen on the Greenland leg, yielded an excellent broad latitude survey of cosmic ray intensity during a time of solar maximum, and, by comparison with some 1953 data, permitted a first indication of the magnitude of solar modulation of the cosmic ray intensity.[34, 35] Three of the successful Pacific rocket flights were in the southern auroral zone, and two of those found the auroral bremsstrahlung, its first observation in the southern hemisphere.[36]

Larry Cahill launched five of his magnetometers during the northward expedition. He considered this primarily a shakedown for his new instrument, but he was also looking for the polar cap ionospheric current that was believed to exist in the neighborhood of the auroral zone. Although Larry had his share of rocket and instrument problems during this leg, he did obtain a successful flight that demonstrated proper operation of the rockoon magnetometer, verified the existence of the polar cap current, and provided some information about its characteristics.[37]

For the Pacific expedition, Cahill had two objectives. The first was to search for the equatorial electrojet in the vicinity of the geomagnetic equator. He conducted six or seven flights in the equatorial region, in the general neighborhood of Christmas Island. Of the five of these flights that produced useful rocket data, three of them confirmed the existence of the equatorial electrojet and provided measurements of its height and current density. He also discovered a second current layer slightly above the main electrojet current from the data from two of the flights.

He also hoped to find the polar cap electrical current in the southern hemisphere, which, if found, would complement his Arctic observation. In the neighborhood of the Ross Sea off the coast of Antarctica, Cahill attempted four flights with somewhat limited success. Two of the flights produced usable data, but he was not able to confirm the existence of the southern polar cap current by direct measurement. Their data, however, did contribute to a more accurate determination of the Earth's main field in the neighborhood of the Ross Sea.

Sputnik!

The Sputnik I launch on 4 October occurred during this 1957 Pacific expedition. The *Glacier* had left Balboa, Panama, and was in the neighborhood of the Galapagos Islands on its way toward Christmas Island, when news of the launch was received. That evening Van Allen was able to listen to the new satellite's signal in the ship's radio room. He has provided a fascinating account of this event in Chapter VI of his 1983 book.[38]

It was only after carefully researching this expedition that I came to appreciate fully the extreme frustration that must have engulfed Van Allen. He was a virtual prisoner on a ship at sea when the momentous first true entry into space occurred. For the next seven weeks, his communication with the outside world was very limited, so that he was unable to follow developments as the U.S. satellite program was modified in response to the Soviet achievement. Some of his reactions during this period of relative isolation, as recorded in his field notebook, included his "disgust with the Stewart Committee's decision to favor N.R.L. over the Redstone proposal of Sept. 1955!!!," and his regret at missing "the inevitable reconsideration and perhaps marked changes of the U.S. program."

To add to Van Allen's woes, only three days after the Sputnik launch, the lymphatic infection in his leg flared up, essentially incapacitating him for the next ten days. Additionally, he was struggling with serious problems with his rockoon instruments.

Van Allen's return to his home and office after this expedition must have been a tremendous relief. This finally occurred on 22 November, and he was at last able to make a long series of phone calls to get up to date on developments. He was immediately caught up in the accelerated U.S. satellite program, and his full analysis of data from the 1957 rockoon flights had to be delayed for many years.

The story of the development of the satellite instruments that had been progressing steadily during the preceding two years is featured in the companion paper.

Reflections

Those involved in the work at Iowa during the 1950's formed a very closely-knit group. We worked in close physical proximity – equipment development was conducted in a crowded laboratory about sixty feet square in the south end of the basement of the old Physics Building. In the later half of the decade, this was expanded to include laboratory space set up in the basement hallway.

During that period, various combinations of us, often joined by Van Allen, gathered frequently for informal discussions, where we freely shared our progress, problems, and aspirations. Our luncheons at the nearby Jefferson Hotel were especially noteworthy, especially after we began to receive the first satellite data, and Van Allen, Carl McIlwain, Ernie Ray, and I struggled to understand the puzzle they presented.

Thanks to Van's organizational philosophy and skill, and his confidence in his staff and students, we were able to conduct our activities with a minimum of formality, paper work, and other bureaucratic impediments. I wistfully recall that I was able to telephone equipment suppliers with purchase order numbers and receive the parts and equipment a day or two later. We were allowed to fly first class when the extra rest it permitted seemed to warrant the extra cost. Other informal arrangements, some of them involving substantial sums of money and other resources, were commonplace. I was never aware of a betrayal of the trust required for such an arrangement to work effectively. The general Iowa City community, from numerous suppliers to the local press, joined in the excitement, and helped us in many ways.

Throughout this entire period, the pressures were tremendous, and we all worked long hours. We made extremely rapid progress and developed a collective sense of challenge, total commitment, and excitement that was never matched throughout the rest of my professional life.

James Van Allen exerted a tremendous influence upon my personal life. He is the one most responsible for helping me to learn my personal approach to scientific research. This encompasses my ability to organize a problem properly, the methodology, skill, and art of laboratory and field research, the taking of useful notes, and the ability to write in a reasonably clear and understandable manner. He also set a wonderful example by his full and untiring dedication to research. This commitment continues today, with his daily appearance in his workroom in Van Allen Hall.

His lessons have stayed with me throughout my entire professional life. When attacking a problem, I frequently find myself musing, "Now, how would Van Allen do this?"

This paper is one way of showing my gratitude for the many ways in which this remarkable man helped to shape my life.

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[3] Van Allen, James A. Energetic Particles in the Earth's External Magnetic Field, History of Geophysics, Vol. 7, p. 235 ff. American Geophysical Union, 1997.

[4] For Byrd's personal account of this rescue see the last dozen pages of: Richard E. Byrd. Alone. Ace Books, Inc., New York, 1938.

[5] For a detailed historical account of the development of the proximity fuse, see: Brown, Louis. A Radar History of World War II – Technical and Military Imperatives. Section 4.4. The Proximity Fuse – The smallest Radar, p 174 ff. Institute of Physics Publishing, Bristol and Philadelphia. 1999. Unfortunately, Van Allen's role is not mentioned in this account.

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[10] A remarkably complete and lucid discussion of the balloon experiment, including instrumentation, calibration, and results, is contained in: Meredith, Leslie Hugh. A Measurement of the Vertical Cosmic Ray Intensity as a Function of Altitude. M.S. thesis. State University of Iowa Department of Physics unpublished research report. June 1952. This was the first thesis prepared by a student under James Van Allen's leadership at the State University of Iowa.

[11] The event is described in: Van Allen, James A. Origins of Magnetospheric Physics, p. 21 ff. Smithsonian Institution Press, Washington, DC, 1983. A somewhat shorter summary is contain in: Van Allen, James A. Energetic Particles in the Earth's External Magnetic Field, History of Geophysics, Vol. 7, pp. 237-238. American Geophysical Union, 1997.

[12] The initial description of the technique is: Van Allen, James A. and Gottlieb, Melvin B. The Inexpensive Attainment of High Altitudes with Balloon-launched Rockets. Rocket Exploration of the Upper Atmosphere, edited by R. L. F. Boyd and M. J. Seaton, p. 53 ff. Interscience Publishers, Inc., New York and Pergamon Press, Ltd., London, 1954.

[13] By far the most complete and detailed description of the rockoon technique is contained in: Van Allen, James A. Rockoon Techniques. Publicly presented initially by this author on Van Allen's behalf at the CSAGI Rocket-Satellite Conference in Washington, DC, 30 Sep. - 5 Oct. 1957. Published under the title Balloon-Launched Rockets for High-Altitude Research in: Newell, Homer E., Jr., Ed., Sounding Rockets, Chap. 9, p. 143 ff. McGraw-Hill Book Company, New York, 1959.

[14] Some details about these early flights were extracted from the account given in: Van Allen, James A. Origins of Magnetospheric Physics, Chap. 2. Smithsonian Institution Press, Washington, DC, 1983.

[15] Extensive detailed historical and anecdotal information about the early rockoon flights was provided by Leslie H. Meredith in the form of published papers, unpublished notes, and several discussions. These include his unpublished personal notes Early Rockoon Research History and his light-hearted personal diary-like paper Arctic Adventure - A Thrilling Saga of the Heroic Feats and Harrowing Experiences of the World Famous Arctic Explorer.

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