

Ralph A. Alpher's Early Career: What Kind of Physicists Were They?

by Victor S. Alpher, PhD

Ralph A. Alpher was a co-founder of Big Bang cosmology, for pioneering calculations linking the expansion of the universe to primordial nucleosynthesis, and predicting the existence of the cosmic background radiation. We are honored to have his son, Victor S. Alpher, tell us his story. This is Part 2.

There is little doubt that my father, Ralph A. Alpher, considered himself a theoretical physicist at a time when there was no discipline of astrophysics and no field of cosmology. Some of the current generation of astrophysicists consider him the “father” of modern astrophysics and cosmology (Neil deGrasse Tyson, personal communication, July 27, 2007). Theoretical physics was the only “niche” in which one could develop mathematical models of the early universe, formation of the chemical elements, and make predictions about phenomena as-yet unobserved in the cosmos.

We will have more to see later when we consider the elaboration of the Big Bang model where his ground-breaking work was confirmed by very sophisticated observations of the expanding universe. Such observations became possible only with the financial support made possible by confirmation of his early theoretical hypotheses. These observations led to four Nobel Prizes, to the launch of the COBE (Cosmic Background Explorer) Satellite in 1989, and, finally, to a National Medal of Science awarded to Ralph A. Alpher himself shortly before his passing on August 12, 2007.

In my first paper in this series, we saw that in 1948 his original work on nucleosynthesis, suggesting in lay terms that the “Universe was created in five minutes”, created a noticeable stir not only in the scientific community, but also in the mass media as well. Dr. Alpher was interviewed on early broadcast television. Through the 1950s he continued with several colleagues to produce major theoretical advances in Big Bang Cosmology. Erroneously, some believed that his “fifteen minutes of fame” had come and gone....

Don't Quit Your Day Job

People with cutting edge, or less-conventional interests, such as musicians, artists, and inventors, are often advised to find a conventional way of earning a living, and sticking to it—until or unless

they become successful with their true passion. By 1948, Ralph Alpher already had nearly 10 years of full-time work in the scientific world of national defense physics as “hired gun”, so to speak. Cosmology was not a recognized subspecialty of physics.

Technically, from 1940 to 1945 he was a contract employee by the Naval Ordnance Laboratory (NOL) (as was Albert Einstein). In fact, he was also working with the scientist-technician teams under Merle Tuve at Section T of the Department of Terrestrial Magnetism of the Carnegie Institution. NOL remained his paymaster, but such shifting around of personnel depending on research needs was common. Lacking only one course in Botany, he had to wait until 1943 to receive his B.S. and appointment at the higher pay grade of Associate Physicist. He had applied for a commission in the U.S. Navy earlier in the war, but was turned town because of his nearsightedness.

When my father responded to a draft call in 1944 (see Fig. 1.), he was deferred because of the essential nature of his work for the Navy on

SELECTIVE SERVICE SYSTEM
AFFIRMATION—OCCUPATIONAL CLASSIFICATION (Industrial)
(Where Occupational Classification is required, Form 45 is required
to be filled out when the form is first filled out.)

Name of registrant: Ralph A. Alpher
Address: 1017 ...
Last born: 7 ...
Title of present job: Dr. Physicist, et al
State whether present occupation is: (checked) essential, () non-essential
Describe duties actually performed: ...
Date employed: 1/1/44 ...
Average number of hrs. per week: ...
Place of employment: ...
Residential address: ...
Statement of essential work: ...

Figure 1. Organizational reply form to Ralph Alpher's Draft Induction Notice seeking deferment based on his work being essential to the war effort. Unless otherwise mentioned, figures come from the personal collection of Ralph A. Alpher, courtesy of Victor S. Alpher

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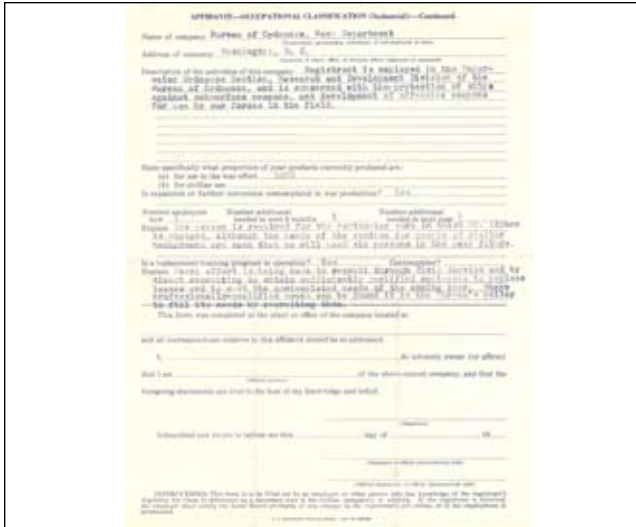


Figure 2. Page 2 of the reply form in Figure 1.

protection of ships from magnetic mines, and projects necessary for personnel in the field (for example, adaptation of the Proximity Fuse to various ordnance—it was used in mortars and artillery in Battle of the Bulge).[1] It is interesting to notice that the Naval Ordnance Laboratory listed his “essential” occupation as “Professional Engineer” on the application for deferment (see Fig. 2).

Solving the Mark 14 Problem

In his final year of war work for the Navy, Ralph Alpher oversaw aspects of the development



Figure 3. Two commendations (top section dated 9 Jul 1945 and bottom section dated 10 Aug 1945, four days before V-J Day in North America) from G. F. Hussey, Jr., to Officer in Charge, Naval Ordnance Laboratory and then from the Officer in Charge, Capt. W.G. Schindler to Ralph A. Alpher for development of mines at the NOL which “have and are currently taking heavy (sic) toll of enemy shipping and have disrupted Japanese industry by blockading large numbers of ships.”

of improved reliability of magnetically-influenced detonation, and improved guidance of Naval torpedoes (the Mark 14, a surface-launched torpedo, and the Mark 13, an air-to-surface launched torpedo). “Duds” were not the only major problem in the previous years of the war—these torpedoes also occasionally swung around to attack the launching vessel![2,3] With the success of other projects at the Johns Hopkins University Applied Physics Laboratory (JUHAPL), his time was freed up by mid-1944 to work on the torpedo problem (see Fig. 3.).

The Mark 9 Torpedo Exploder

Dr. J. E. Henderson, Director of the Applied Physics Laboratory of the University of Washington at Seattle, led the Section T work on what became known as the Mark 9 torpedo exploder in collaboration with JHUAPL, where this work was led by Wilbur Goss. My father was “Project Supervisor, Production Problems” during his year with the Mark 9 Torpedo Exploder Group (Fig. 6).

Henderson was no stranger to Section T, and since 1940 had worked on “influence” (magnetic and radio wave) detonation. Because the Mark 9 TE was so advanced, correcting for problems with yaw, pitch, roll, and broaching, many of its characteristics are still classified.[4] During this time, my father traveled to Puget Sound to observe torpedoes in action from a small wooden boat, which often proved dangerous as errant torpedoes “broached” and deviated from their intended courses (Fig. 4). The life of a physicist in this kind of testing work appeared on the surface to have an equivalent value to that of a Marine or Ranger storming an occupied and heavily fortified beach. The Mark 9 TE was required to have a 99% reliability—the difference between even a 95% and 99% reliability being very significant. It took a year to achieve that goal. Ralph did not become an official employee of JHUAPL until the end of the



Figure 4. Mercury lamp used by Ralph Alpher while testing torpedoes in Puget Sound during World War II. If it was necessary for the testing crew to abandon their wooden boat, this lamp would emit a faint blue signal at night that could be seen by rescue teams.

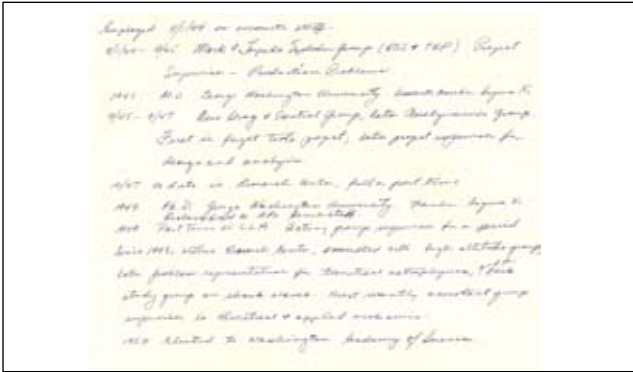


Figure 5. Handwritten notes by Ralph Alpher concerning his activities from August 1, 1944 through about 1950.

war.

From that point onward, he worked on several projects, which will be described further (Fig. 5). However, like many of the scientists who were recruited for work on ordnance projects and other war-related research, my father faced a difficult problem. Having won its notoriety on military projects during the war, afterward JHUAPL devoted only five percent (5%) of its budget to scientific research involving rockets acquired from Germany's V-2 program.

Onward to High Altitude Research and Guided Missiles

When World War II ended, Section T (rumored to be named for its director, Merle Tuve) became officially the Applied Physics Laboratory of Johns Hopkins University, the first free-standing laboratory-for-hire of its type in the United States. By this time, many scientists and their military liaisons were involved in chronicling as quickly as possible the scientific developments brought on by the need for advancement in ordnance capabilities during the war.[5,6]

Initially, after the war, all unused V-2 rockets were brought to the U.S. for testing at the White Sands Missile Range in New Mexico. During this time, many of the German scientists who had worked with Wernher von Braun, first at the Kummersdorf[7] artillery testing range, and then at Pennemünde, lived at Fort Bliss, Texas. (Removal of Germans who could be useful to the U.S. military and intelligence was called Operation Paperclip). Before the supply of V-2s was exhausted, other missile designs based on the V-2 followed. My father also worked on the Terrier and Talos guided missiles, which were developed and studied during part of the time that he worked in James van Allen's High Altitude work group at JHUAPL. The Talos surface-to-air missile first flew in 1951.

All such projects had a double purpose. In

the case of James van Allen's rockets, they supplied information about their characteristics as rockets and guided missiles that would carry nuclear warheads. Equipment in the empty warhead also provided data on a variety of scientific projects approved by the people directing the "V-2 Panel." This often led scientists without the right "connections" out in the cold for conducting space research. The "five percenters", as they were called,[8] struggled under the leadership of James van Allen to piggy-back high altitude scientific research materials into the empty warheads of sixty-six V-2 German rockets, and on van Allen's own Aerobee between 1946 and 1951. The multi-institutional "V-2 Panel" directed scientific research aboard these rockets, first meeting officially on February 27, 1946 at Princeton, New Jersey. Van Allen was its second director, from late 1946 through 1957. On a shoestring budget, from 1946 through 1951, a number of purely scientific results emerged from what was renamed the Upper Atmosphere Rocket Research Panel.[9]

Merle Tuve saw the potential of space science not directed toward immediate practical or commercial findings. However, the atmosphere at JHUAPL was increasingly tilted in the direction of military ordnance and technology, so much so that Tuve returned to non-military science at the Department of Terrestrial Magnetism in 1950. As the Cold War and Korean conflicts loomed, a new director, Ralph Gibson, was keenly devoted to seeing JHUAPL return to its glory days of the development of the Proximity Fuze. This was fortuitous for the laboratory, but not necessarily for scientists "at heart" who had diverted so much of their creativity in the direction of military ordnance. During the ensuing several years, a number scientists left the lab, beginning with Merle Tuve in 1950, and also with van Allen, who returned to the University of Iowa as Chairman of the Department of Physics in 1951.

As Ralph Alpher worked with James van Allen's high altitude work group at JHUAPL in the late 1940s, the characteristics of cosmic rays were investigated miles above the earth's surface, before their breakup in the upper atmosphere. This also made necessary the further sophistication of telemetry that would become the hallmark of advanced rocket research. The ozone layer that protected the planet from ultraviolet rays was discovered, as well as nuclear reactions in solar flares. Space walks, which we take for granted now, were found to pose great danger to astronauts and cosmonauts during solar flare activity. Because of this early research, space walks are prohibited during such times.

Meanwhile, at night and on weekends my father also avocationally pursued astrophysics and

cosmology the subjects of many peer-reviewed publications, colloquia, and media attention. However, he also learned during his early career that scientific research at the laboratory would always be the stepchild of military deep pockets—particularly at free-standing laboratories beholden to the government for meaningful research support and to companies at the vanguard of space science, such as Lockheed and General Electric.

George Gamow Takes on an New Student

After receiving his bachelor's degree in 1943, Ralph Alpher successfully appealed to George Gamow to become his thesis advisor and dissertation director. This put him in a direct intellectual line of cosmological inquiry going back through George LeMaître and Gamow to Aleksander A. Friedmann in the early 20th century. Ralph brought to the enterprise a level of mathematical genius not yet applied to the questions at hand.

Fortunately for the fledgling cosmologist, the nascent military-industrial complex provided a solid income during a period of time when he earned his bachelor's, master's, and doctoral degrees at George Washington University at night, while working during the day at the National Bureau of Standards, the Carnegie Institution, the Naval Ordnance Laboratory, and finally, the



Figure 7. Ralph A. Alpher and Robert C. Herman working on a problem at a chalkboard sometime in the late 1940s or early 1950s.

reputed to be a hard drinker: it was not Ralph).

In the 1940s, Washington, D.C. was a good place to be studying Physics, because of the creativity of the people he came in contact with early in his career, such as Merle Tuve, Robert and Vera Rubin, George Gamow, James van Allen, Freeman K. Hill, Robert Herman, Scott Forbush, and Wilbur Goss, just to name a few. His freshman physics course was taught by Edward Teller, who had emigrated to the U.S. from Hungary in 1935 and, like Ralph Alpher, was something of a prodigy in mathematics.

By 1945 Germany had advanced far beyond the U.S. in the development of rocketry and missile technology.[10,11,12] My father began immediately to work on the ram-jet after the war, one of several candidates for further development. Rockets and missiles, of course, are distinguished from bombs in that the former have their own propulsion and guidance systems. Earlier in the run-up to the war beginning with formation of the OSRD in November, 1940 (at which time the U.S. Government professed caution and neutrality), my father had already done considerable work (as an undergraduate!) on detonation technology--most significantly on the Proximity or VT (variable time) Fuze, as well as on torpedo propulsion and detonation, and degaussing Navy and Merchant Marine vessels.

Just a Side Trip to New Mexico

Later in the war, my father was assigned briefly to the secret facility at Los Alamos, New Mexico, where he was involved in formulating and making calculations to determine the altitude for each atomic bomb (Little Boy and Fat Man) to detonate for maximum desired effect. He often said to me that "somewhere there is a photograph of me with Fat Man" (the second of the two bombs,

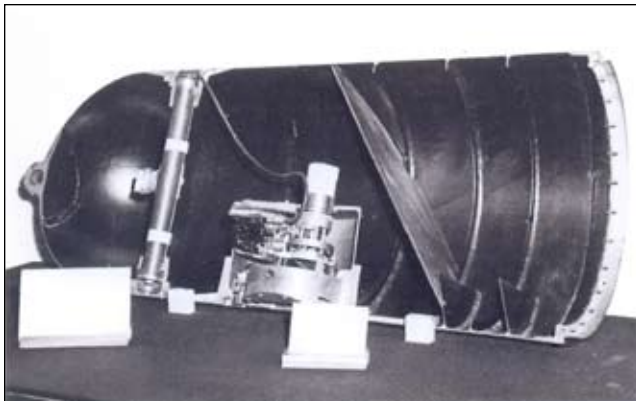


Figure 6. Photograph of the Mark 9 Torpedo Exploder Mechanism.

Applied Physics Laboratory of Johns Hopkins University. From photos I have seen, I believe my father's favorite "office" was the space in front of a long blackboard. The location of that blackboard, whether in a converted used car garage (JHUAPL on Georgia Avenue) or a majestic U.S. Government structure, was of secondary significance! At times, a pub napkin would do—meetings with his advisor, George Gamow, a Soviet defector and a JHUAPL consultant, often occurred at lunchtime in Silver Spring, Maryland, at the converted Wolfe Garage, or in the evening at a pub or corner bar in the vicinity of G.W.U. (only one of the two men was

dropped over Nagasaki, Japan). He also told me that he designated the trajectory, flight path, and speed of the Enola Gay after dropping the bombs.

This was necessary so that this stripped B-29 bomber would not be blown apart by the shock waves following the detonation of the two bombs above each city. This was the first of many studies of shock waves and blast effects that he would make in the ensuing fifteen to twenty years. Back in Maryland, he also conducted research on early warning of ballistic missile attack, and later worked at General Electric on problems of the protection of missiles during atmospheric reentry.

For the next ten years (1945-1955), my father continued working at JHUAPL, and quite productively, keeping a list of his major writings and collaborations over the years. During the war, with Freeman K. Hill, he had translated Robert Sauer's *Introduction to Theoretical Gas Dynamics*[13,14,15] which, though initially restricted, was eventually published in English in 1947, as well as several other languages (French, Russian). Sauer's exposition was undoubtedly important for my Dad's later work and that of Freeman Hill. Examination of a partial list of reports written by Ralph A. Alpher, solely or in collaboration with others, shows clearly that by 1955 he would have been considered an expert on guided missiles, interaction of shock waves with moving targets, air flow characteristics around missiles, percussive blast effects, the use of radar in target acquisition, telemetry, and other applications of refined wartime technology.

By 1951 my father was already becoming familiar with the use of shock tubes in the study of damage from pressure blasts. He continued to work in later years with shock tubes in collaboration with Don White at the General Electric Corporate Research and Development Center (GECRD). So, although he had completed a great deal of theoretical work on the Big Bang by the mid-1950s (Figs. 7, 8, 9), he and one of his major collaborators, Dr. Robert C. Herman, seemed to go separate ways when Herman left JHUAPL for the General Motors Research Laboratories in Michigan, and Ralph Alpher left for GECRD in Schenectady, New York. Such an assumption would have been quite misleading.

My father had applied for positions at the University of Iowa in Iowa City (where James van Allen was chairman), Lawrence Livermore Laboratory (where Edward Teller was employed), California Institute of Technology, the Glenn L. Martin Company,[16,17,18] and other quasi-independent laboratories that had sprung up with government financing. These attractive institutions drained many scientists from academia during the 1950s with better pay and better research funding. My

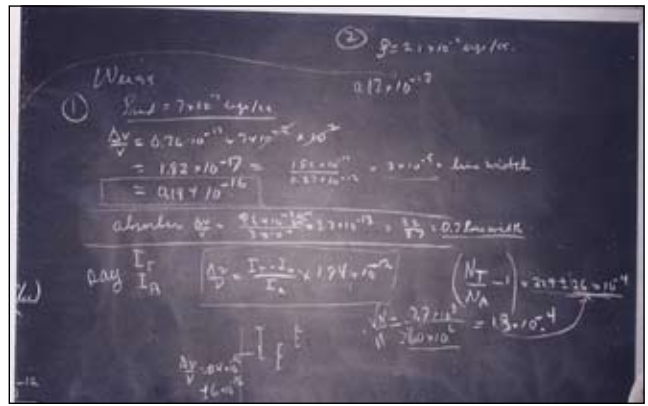


Figure 8. Polaroid Land Camera photograph of some blackboard calculations done in preparation for a paper on the Finlay-Freundlich Red Shift Hypothesis.

Dad continued to be very productive, publishing and writing Big Bang and guided missile-related papers. Unfortunately, much of his written work for JHUAPL was Classified and had limited distribution which continued to be a problem when he was with the General Electric company (including the constraints of limited distribution of work in which GE had a proprietary competitive interest). And to this day, much of the detailed work remains Classified.

Eisenhower Follows the Lead of Vannevar Bush and FDR

Fully informed and impressed by the contributions of basic science to the fairly rapid conclusion of World War II, President Dwight D. Eisenhower was not ambivalent about the need to fund scientists as part of an overall national defense plan. In fact, he virtually gave *carte blanche* to such contracts and funding, particularly with Lockheed and the General Electric Company.[19] Much guided missile work was done under the veil of preparing for the International Geophysical Year in 1958.[20] Although the Eisenhower administration is sometimes thought of as a quiet and restrained period of little government activity and a burgeoning domestic economy, funding of defense work in the private sector grew tremendously.

The advent of the Cold War gave further opportunity for scientific research to come under the wing of military projects. The General Electric Company and Lockheed were major beneficiaries. Nonetheless, my father was concerned about the small amount of time he had available to devote to his strong interest in cosmology (he had successfully petitioned for short period of leave to study for his doctoral comprehensive examinations in 1946). He turned down the opportunity to contribute a major chapter on "nuclear geology" for a book being assembled (despite being offered essentially



Figure 9. While working at Johns Hopkins University Applied Physics Laboratory, Ralph A. Alpher continued to spread the word of advancements he had made in his work on cosmology as time permitted. This spritely flyer announces an evening talk at the Philadelphia Electric Co. on March 12, 1951.

“no deadline” after declining), citing the extensive demands made on his time by the military work at JHUAPL.

Military-industrial work (the “military-industrial complex” was a term of caution advanced by Eisenhower in his farewell speech to the country three days before leaving office in 1961) occupied the bulk of my father’s work commitment.[21] My Dad’s drafts for letters inquiring about employment opportunities also stressed the exodus of major scientists from the climate at JHUAPL, about which he offered to be more specific, off the record. The departure of Tuve and van Allen were, of course, well-known, but job-seeking efforts by others were still confidential and developing.

The importance of having an established scientific community prepared to work in liaison with the military-industrial complex was well accepted at the highest levels of government, a legacy we owe as much to Vannevar Bush, Director of the Office of Scientific Research and Development (OSRD) as to anyone.[22,23] My Dad benefited from this *Zeitgeist*, and had been at the center of this environment for more than fifteen years in Washington, D.C.

As a brief aside, we should consider in context the history of missile and rocket research. As one area not prohibited for development by the Treaty of Versailles at the end of World War I, Germany embraced the development of rocketry long before other countries. Its potential for weapons technology was recognized long before World War II, and the German government supported and funded its early pioneers, such as Wernher von Braun and Walter Dornberger. One of our own experts familiar with the developments in Germany concluded: *“If the guided missile had*

not been developed as a weapon, it would have been necessary to develop it as a stepping stone to space flight”[24] (italics in original, p. 59).

There can be little doubt that the Cold War accelerated the transition to space flight, and the United States was propelled into this area once the level of German advancement was known. A good deal of the technology we take for granted today has its origins in research funded for military and national security purposes. From my own experience, I believe that most scientists working in this arena accepted this as a necessary aspect of their research progress. However, advances also occurred at a time when these multiple uses of research were broadly and generally understood and accepted, including the employment of former enemies when it was necessary to gain an edge[25,26]

When Dad applied for a position at the University of Iowa his JHUAPL colleague James van Allen was working hard to be productive with limited funds, using weather balloons as launch pads for rockets, even though he had designed the successful but relatively expensive Aerobee. Two of his early hires as chairman left Iowa for the well-funded Argonne Research Laboratory west of Chicago. My Dad also applied for positions at other institutions that were doing much defense work, and his curriculum vitae was replete with related experience. He requested a reference from Edward Teller, while also inquiring about job opportunities at Berkeley, which ran Lawrence Livermore Laboratory.

On to General Electric under Dr. Guy Suits

Dr. Guy Suits, Vice President and Director of Research and Development at G.E., was a significant person in the direction of my father’s continuing career (Figs. 10, 11). Dr. Suits was very positively disposed to people like my father whose primary identity was in the basic sciences.[27] This was more consistent with Merle Tuve’s attitude—and contrasted diametrically with one Tuve’s significant successors at JHUAPL in the 1940s, Ralph Gibson.

During the war, Dr. Suits had also been Director of Division 15 (Radio Coordination) of the National Defense Research Committee, which was involved with promulgating for the Allies a wide range of electronic countermeasures to enemy communications. Therefore, he had seen the effects of “scientists against time” in winning World War II. Dr. Suits was on leave from G.E. from 1942 to 1945; therefore he had more than a passing familiarity with the kind of research environment my father worked in during and immediately after the war.

Perhaps more significant was Dr. Suits’ deep

knowledge and appreciation of the difficulty of determining the “value” of output from scientific research and the absolute necessity of giving scientists a free reign to determine their major activities, to follow their passions and hunches—even if practical, bottom-line results were not immediately obvious. Business models developed in the leading business schools later on would not permit such philosophically-driven activity of publicly-owned companies. At any rate, the climate at GECDR was quite different from that at JHUAPL.

Regarding this climate in support of research, Dr. White commented that a degree of “GE relevance was always shown at Program Reviews, but it could be tenuous and was not questioned.” I believe, from my own observations of my father at work during my childhood and adolescence, that he concluded during his job search of 1954-1955 that General Electric Company would provide him the most professional and intellectual freedom. This included support of community activities, which were substantial and will be addressed in my next paper. The General Electric Company had a long history of supporting a breadth of activities by its scientists.

Despite other job offers (including the Glenn L. Martin Co., from which he received an invitation to re-apply at any time), and the Knolls Atomic Power Laboratory, funded by the Atomic Energy Commission and administered by G.E.), my Dad was eventually hired into a small group of specialists directed by Dr. Anthony Nerad at the GECDR, working under an Air Force Ballistic Missile Division contract. The main purpose of the contract was to study the characteristics of missiles re-entering the atmosphere after a space flight. It was hoped that they could provide support for acquisition of a ballistic missile development contract by the Philadelphia division of G.E. (Dr. Donald White, personal communication, June 7, 2008).

My Dad’s long period of collaboration in cosmology with Robert Herman, now with General Motors, continued, supported by almost-daily telephone calls on WATS lines (fairly inexpensive long-distance telephone lines used primarily in industry in the 1950s through 1980s). Together, they continued to publish major theoretical papers on the early Universe, and talked almost daily until Herman’s passing in 1997. I will pick up on the parallel thread of work in cosmology and astrophysics in the next paper.

So, for the first twenty to twenty-five years of his career, Ralph A. Alpher worked within the burgeoning military-industrial complex, while keeping up also with developments in cosmology and astrophysics. He managed to retain his primary



Figure 10. Photograph at the General Electric Research and Development Center around 1958. Left to right: Dr. Bob Johnson, unidentified G.E. Staffer, Ralph A. Alpher, and Irving Langmuir (Nobel Prize-winner and inventor of ASDIC).

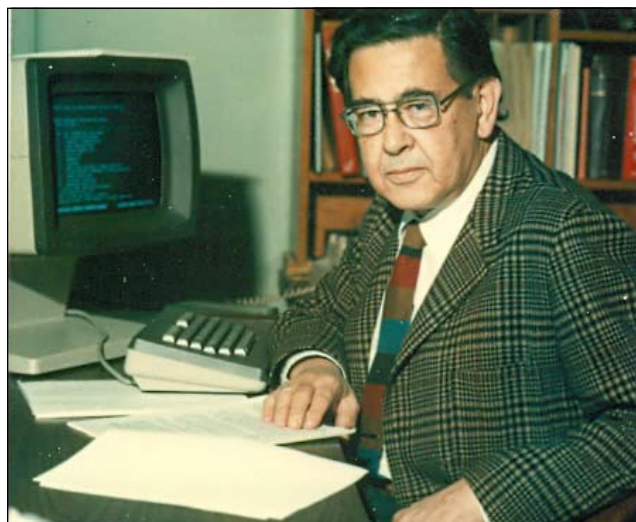


Figure 11. Photograph of Ralph A. Alpher in the 1970s, in his office at the General Electric Research and Development Center. Note the CRT on his desk, which was an early desktop PC.

identity as a theoretical physicist and cosmologist. Very shortly, an observation of the Cosmic Microwave Background Radiation (CMBR) in 1964 would have a major impact on his life and career. Ironically, this probably was not the first observation of the CMBR, a subject I will take up in the third of this series of papers.

After joining Dr. Nerad’s group, a considerable amount of his written work for several years at G.E. involved magnetohydrodynamics. Magnetohydrodynamics and hypersonic aerodynamics expertise were needed to develop a protective nose cone on a ballistic missile re-entering the earth’s atmosphere. Don White had been devoted to work on shock waves using a shock tube as an experimental model, to which my father also began to

contribute. Although he considers the work in retrospect highly speculative, Dr. White asserts that at the time any possible method to enhance re-entry was being considered (personal communication, June 20, 2008).

By the early 1970s, my father began to become involved in other aspects of the GECD's mission, including technology forecasting. He also devoted more time to professional activities, such as the funding of science education in New York State, and employment of new Ph.D.s in physics with the American Physical Society, to which he had been elected a councillor.

My father's long years of work in a variety of technical areas did lead to one prominent commercial application. He and a group at GECD received an award for the development of the first large screen television—long before “instant replays” at sports events were expected by large crowds at professional and collegiate games (he was co-recipient of the I-R 100 Award in 1968 for G.E.'s Model PD400 Large Screen Color Television Projector). However, one can easily see that his major professional activities, sometimes taking a second seat to his recognition for predicting the CMBR, were probably as significant in their own way as those of any Marine who stepped on the volcanic soil of Iwo Jima. At times, it seems as though I have observed the career of two physicists. Perhaps, considering Robert Herman's own eclectic career, I have witnessed up close the work of four or five very talented men. No doubt I have had a privileged vantage point.

The scientists of Dad's generation gladly gave a substantial portion of the time of their early careers, when the majority of scientists are most productive and original, to the service of a country during its times of greatest need for “brain power.” In retrospect, my Dad had the unique opportunity to work on countermeasures to the greatest perceived threats from Germany—magnetic mines and torpedoes—and Japan—airplanes dropping air-to-surface missiles, and Kamikaze airplane raids. [28] Degaussing and the Proximity Fuze accomplished these enormous tasks. He also worked on the development of a missile defense system that became second to none. My maternal grandfather was a Marine during World War I, and his son a Naval officer during World War II. Although my father at times seemed disappointed at not having been able to obtain a Navy commission, he clearly gave service where he could possibly do it best, over at least a twenty-five year period. By the 1970s, he also started to receive significant recognition, belatedly, for his work in cosmology and astrophysics. Finally, by January 1, 1987, when he became Distinguished Research Professor of Phys-

ics at Union College, he could devote all of his time to these fascinating and important fields.

Acknowledgements

Without many hours of patient discussions with my father about his work and issues raised throughout his career, this paper would have suffered greatly. I can only hope it conveys the spirit of scientific inquiry and curiosity that characterized him. I would like to thank Dr. Dwight Neuenschwander for his shepherding of this project, to Prof. Dr. Robert Bauer for information on the career of Dr. Robert Sauer, and my wife Tatyana for her kind support of this research and many kindnesses to my father in his late life. Also, I have profited immensely from conversations with military veterans of World War II. Dr. Don White, who worked closely with my father at GECD, also provided important consultation and information about their work together in Dr. Tony Nerad's group.

Footnotes

1. Baldwin, Ralph. *The Deadly Fuse. Secret Weapon of World War II*. San Rafael, CA, Presidio Press, 1980.
2. Newpower, Anthony. *Iron Men and Tin Fish*. Westport, CT: Praeger Security International, 2006.
3. Gannon, Robert. *Hellions of the Deep*. State College, PA: Pennsylvania State University Press, 1996.
4. Boyce, Joseph C. *New Weapons for Air Warfare*. Part of a series of publications on science in World War II sponsored by the NDRC and OSRD, covering the work of Divisions 4, 5, and 7 of NDRC, and Section T, OSRD. Boston: Little, Brown & Co., 1947. By employing principles of the Proximity Fuze, stated J. A. Hynek, author of the Section T chapter, “prove-in tests of the Mark 9 provided a spectacular finish to a hectic development and production program” (p. 166). These were intended to explode under the keel, “breaking the back” of vessels attacked and sending them swiftly to the ocean bottom. A spectacular dramatic version of such an keel attack (based on the real wartime reporting of Lothar Günther-Buchheim, Marinekriegsbericht (Naval War Reporter) for the Kriegsmarine on a wartime patrol aboard U-96) on the keel can be seen in the hugely successful German film about U-Boat warfare, *Das Boot* (1981), see www.imdb.com.
5. Davis, Leverett, Jr., Follin, James W., Jr., & Blitzer, Leon. *Exterior Ballistics of Rockets*. Princeton, NJ: D. Van Nostrand Co., Inc., 1958. The complexity of analyzing rocket ballistics is amply illustrated in Appendix A, which lists a staggering quantity of symbols for variables that may affect even a simple rocket's course. The authors note that classification difficulties would be inherent in any update of this text, the majority of which was actually written in 1946, when it was realized that much of the mass of scientific information produced under OSRD contracts needed to be assembled and written down in some systematic way.
6. See, for example, the many reports of the twenty-three administrative divisions, panels, and committees of the National Defense Research Committee, published following the war and classified originally as SECRET under the meaning of the Espionage Act, 50 U.S.C. 31 and 32, as amended, numbering eventually some seventy or so volumes. Of related interest see also Boyce, Joseph C. (Ed.), *New Weapons for Air Warfare: Fire-Control Equipment, Proximity Fuzes, and Guided Missiles*. Boston, MA: Little, Brown and Company, 1947; and, Baxter, James Phinney, III, *Scientists Against Time*. Boston, MA: Little, Brown, and Company, 1948. These works amply demonstrate how scientific research within industry and academia became

intertwined with national defense for the first time, leading to what President Eisenhower termed the military-industrial complex in 1961 (see below).

7. Fleischer, Wolfgang. *The Wehrmacht Weapons Testing Ground at Kummersdorf*. Atglen, PA: Schiffer Military History, 1997. Translated from the German by David Johnson. Originally published as *Die Heerenversuchsstelle Kummersdorf* by Podzun-Pallas Verlag.

8. Foerstner, Abigail. James van Allen. *The First Eight Billion Miles*. Iowa City: University of Iowa Press, 2007.

9. *Ibid.*

10. Locke, Arthur S. Guidance. In Merrill, G. (Ed.), *Principles of Guided Missile Design*. New York: D. Van Nostrand., 1955.

11. Department of the Army Technical Manual TM 9-1985-2 and Department of the Air Force Technical Order TO 11A-1-26. *German Explosive Ordnance (Bombs, Fuzes, Rockets, Land Mines, Grenades and Igniters)*. Washington, D.C.: Government Printing Office, 1953.

12. Department of the Army Technical Manual TM 9-1985-3 and Department of the Air Force Technical Order TO 39B-1A-10. *German Explosive Ordnance (Projectiles and Projectile Fuzes)*. Washington, D.C.: Government Printing Office, 1953.

13. Sauer, Robert. *Introduction to Theoretical Gas Dynamics*. Translated by Freeman K. Hill and Ralph A. Alpher. Ann Arbor, MI: J.W. Edwards, 1947. Originally published in 1943 by Springer-Verlag, Berlin.

14. Bauer, Friedrich L., & Schmidt, G. (eds.) (n.d.). *Erinnerungen an Robert Sauer*. Collection of papers in memory of Robert Sauer, a volume of papers presented following a conference in memory of Robert Sauer's life and work on 20 October, 1980. Berlin, Germany: Springer-Verlag.

15. Bauer, Friedrich L. (ed.). Robert Sauer and Klaus Samelson. Papers collected following a memorial colloquium on 5 October 1990. Club Informatik. E. V., Prof. Dr. Christoph Zenger, Director : 1999.

16. Letter dated 4 October, 1952 from Ralph A. Alpher to Dr. Henry Paul at the Radiation Laboratory, U.S. Geological Survey regarding a proposal for a book on "nuclear geology" in which Dr. Henry requested a chapter from Dr. Alpher. In this letter, he mentions as the primary reason for declining that the "work in our Laboratory on *military and associated problems* (italics added; he had also referred to the great demands of his work at JHUAPL in his first response to Henry dated 31 July 1952) is occupying more and more of my time" noting that "what spare time I have is devoted to the furtherance of two research problems which I should like to complete while they are still of interest" (nucleosynthesis and the CMBR). My Dad also noted that he was already committed to "one or two" articles for the *American Journal of Physics* and a "commitment of long standing for the preparation of a book" and therefore he had "no hope of fulfilling even these commitments in the foreseeable future." He also recommended a possible author for a chapter on nucleogenesis, referring to two review articles on which he was a coauthor with Dr. Robert Herman in the prior two years. A year later, on 25 October 1953, he nonetheless provided an extensive and thoughtful commentary on the chapters then assembled by Dr. Henry-which gives you an idea about how he treated projects to which he was not even committed.

17. Letter from J.J. Holley, Technical Employment Manager, The Glenn L. Martin Company, dated 20 August, 1955, regarding my father's decision to decline the company's offer of employment. Holley requested that he feel free in the future to reopen his application to the company, as "we should be more than pleased to have the opportunity to consider you."

18. Both the letter from Holley and his correspondence with Henry support the observation that cosmology, from graduate

school forward, was an "after hours" endeavor which though groundbreaking, never threatened his primary vocational commitment. This meant days consumed with thinking about contemporary developing military problems, which, following the war through the mid-1960s, involved guided missiles and national defense.

19. Taubman, Philip. *Secret Empire. Eisenhower, the CIA, and the Hidden Story of America's Space Espionage*. New York: Simon & Schuster, 2003.

20. Foerstner, *ibid.*

21. Eisenhower, Dwight D. *Public Papers of the Presidents*, 1961.

22. Baxter, III, James Phinney. *Scientists Against Time*. Boston: Little, Brown, & Co., 1948.

23. See also <http://history.sandiego.edu/GEN/WW2tlME-LINE/OSRD.html> for an excellent summary of the overall accomplishments of the Office of Scientific Research and Development.

24. Ehricke, Krafft A. *Space Flight. I. Environment and Celestial Mechanics*. A Volume in the Series *Principles of Guided Missile Design*, Capt. Grayson Merrill, U.S.N. (Ret.), Editor. Princeton, NJ: D. Van Nostrand Co., Inc., 1960.

25. Schaffel, Kenneth. *The Emerging Shield and The Air Force and the Evolution of Continental Air Defense, 1945-1960. Office of Air Force History, Washington, D.C.:* 1991.

26. Cornwell, John. *Hitler's Scientists: Science, War, and the Devil's Pact*. New York: Viking Press, 2003.

27. Suits, C. Guy. *Speaking of Research*. New York: John Wiley & Sons, 1965.

28. German magnetic influence torpedoes became better and better from 1939 to 1942, at a time when U.S. Navy torpedoes performed poorly, and degaussing was the only protection available. Although there is evidence that Germany used degaussing during shipbuilding, there was no effort to continue this measure once vessels were launched. I believe the greater U.S. concern with Germany was due to the sinking of Navy and Merchant Marine ships by U-Boats, even when the U.S. was neutral, just off of the eastern coast of the country. The Japanese Navy never posed a comparable threat. However, the Proximity Fuze neutralized the threat of Japanese Naval Aviation after the use of the first proximity-fuzed anti-aircraft shells on the *U.S.S. Helena* in January, 1943. Ironically, the Japanese received little technical assistance from their ally, Germany, and Japanese Army and Navy tradition, ironically, eschewed the scientists and technical advancement.

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