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SAMUEL ABRAHAM GOUDSMIT
1902—1978

A Biographical Memoir by
BENJAMIN BEDERSON

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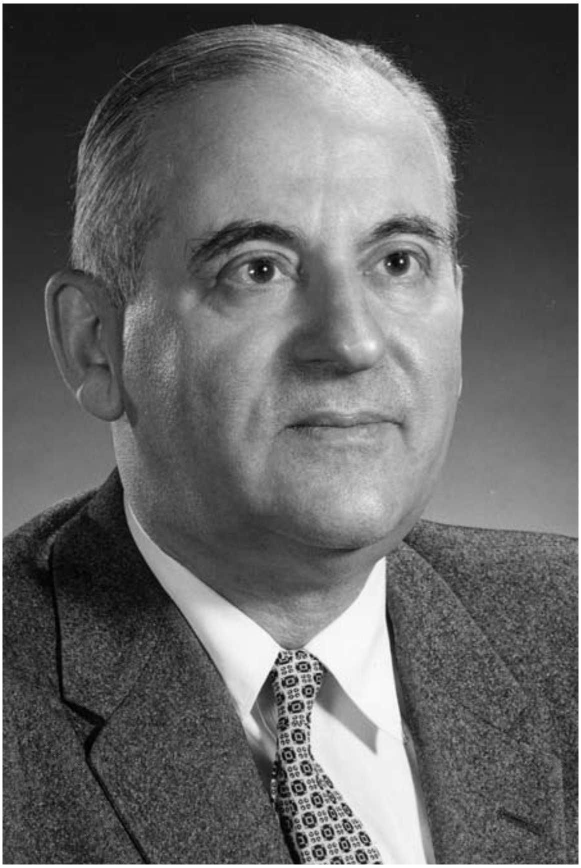
Biographical Memoir



Photograph courtesy Brookhaven National Laboratory.

S. A. Goudsmit

SAMUEL ABRAHAM GOUDSMIT

July 11, 1902–December 4, 1978

BY BENJAMIN BEDERSON

Sam Goudsmit led a career that touched many aspects of 20th-century physics and its impact on society. He started his professional life in Holland during the earliest days of quantum mechanics as a student of Paul Ehrenfest. In 1925 together with his fellow graduate student George Uhlenbeck he postulated that in addition to mass and charge the electron possessed a further intrinsic property, internal angular momentum, that is, spin. This inspiration furnished the missing link that explained the existence of multiple spectroscopic lines in atomic spectra, resulting in the final triumph of the then struggling birth of quantum mechanics.

In 1927 he and Uhlenbeck together moved to the United States where they continued their physics careers until death. In a rough way Goudsmit's career can be divided into several separate parts: first in Holland, strictly as a theorist, where he achieved very early success, and then at the University of Michigan, where he worked in the thriving field of precision spectroscopy, concerning himself with the influence of nuclear magnetism on atomic spectra.

In 1944 he became the scientific leader of the Alsos Mission, whose aim was to determine the progress Germans had made in the development of nuclear weapons during World War II.

After the war, the scope of his work expanded when he became head of physics at Brookhaven National Laboratory. As though this wasn't enough, he then became first editor and then editor in chief of the American Physical Society (APS), where among other things he was responsible for the founding of *Physical Review Letters.* Upon retirement in 1972 from APS he rounded out his career as Distinguished Visiting Professor at the University of Nevada Reno.

While nominally a theorist, he was an occasional participant in experimental research, always a tinkerer and among many other contributions is responsible for the invention of a time-of-flight magnetic mass spectrometer.

Goudsmit was an intensely active person; he was known for his strong feelings, his compassionate character, his intense abhorrence of the Nazi regime, and his belief in both academic and personal freedom, and with all this, his deeply felt modesty and humility in all he had achieved. He was a prolific writer. Fortunately for us he was also an avid collector of many things, including copies of much of his voluminous correspondence. An extraordinarily complete collection of his archives therefore exists, deposited at the Niels Bohr Library at the Center for History of Physics at the American Institute of Physics in College Park, Maryland. This collection consists of no fewer than 30 linear feet of material, a goldmine for historians of physics and an unusually complete summary of his life and times (see Appendix 1).

Goudsmit was born in The Hague, The Netherlands, on July 11, 1902, of Jewish parents, Isaac and Marianne (Gompers) Goudsmit. As he was proud to claim throughout his life, his father was a small manufacturer of water-closet fixtures while his mother ran a millinery shop. His early scientific education was at the University of Leiden, where he had the good fortune of acquiring the great Dutch-Austrian physicist Paul Ehrenfest as mentor. Professor Ehrenfest was both an outstanding scientist and an extraordinary pedagogue who devoted much of his energy to the nurturing of his young students. Under his tutelage Goudsmit published as sole author his first paper at age 19 in the prestigious journal *Die Naturwissenschaften* (1921). Its subject, the influence of relativistic effects on atomic spectroscopic doublets, was already a foretaste of one of Goudsmit's most important research interests throughout his career, and was a direct antecedent of his later paper on electron spin. During the years 1921-1925, Goudsmit published at least 10 papers, with and without coauthors, in a variety of Dutch and German journals, and even one in *Nature* in English. Most of his papers were written in Dutch. Later he half-jokingly would suggest that Ehrenfest wanted to encourage him in his research but also wanted to be sure that his papers weren't too broadly read!

The story of how the discovery of spin came about is best told in Goudsmit's own words. These appear in a talk he gave at a celebratory anniversary of the Dutch Physical Society in 1971 (*http://www.lorentz.leidenuniv.nl/history/spin/goudsmit.html*). His self-deprecating humor is clearly demonstrated. In this article, referring to the relative contributions to the discovery by Uhlenbeck and himself, he first explains that the more formally trained but less experienced Uhlenbeck was not immersed in current atomic research. Upon Goudsmit's referring to leading figures such as Paschen, Heisenberg, and Landé, Uhlenbeck responds, "Who is that?" While when Uhlenbeck remarked, "That means a fourth degree of freedom," Goudsmit responds, "What is a degree of freedom?" Then, however, Goudsmit goes on to say, "That fits precisely into our hydrogen scheme . . . if one now allows the electron to be magnetic with the appropriate magnetic moment, then one can understand all those complicated Zeeman-effects."

As Goudsmit points out, the American physicist (though born in Germany) Ralph Kronig (1904-1995), who was in residence in Leiden at the time, had also considered the possibility of spin. However, he lacked the detailed knowledge of atomic spectra that enabled Goudsmit to make a convincing connection with experiment and was discouraged from publishing by Pauli, who felt the concept to be unrealistic. In response to Goudsmit and Uhlenbeck's paper, in fact, Kronig published two articles attempting to refute the concept. A. H. Compton also had speculated on the possibility of a quantized electron angular momentum years earlier though on erroneous grounds and again with no convincing connection to experimental results. In later years Goudsmit credited Uhlenbeck as the more gifted formal theorist of the two, but the actual assignment of an additional internal quantum number, due to the electron spin, was Goudsmit's idea. At the same time he credits his own ignorance with the willingness to submit their paper for publication because the model of a spinning electron possessing the required angular momentum and magnetic moment (which must accompany a spinning charge) implies a surface velocity that exceeds the speed of light, and hence must be impossible. It was only later that the English theorist L. H. Thomas showed that relativity did indeed yield the correct magnetic moment, although it was the fully relativistic Dirac equation, in 1930, that yielded the correct spin and magnetic moment from first principles. Despite Pauli's original reaction he and Werner Heisenberg were quick to realize that electron spin fit perfectly, along with Pauli's newly discovered exclusion principle, into a consistent explanation of the nature of atomic spectra and energy levels of many atomic elements. It was the missing link that solidified the entire edifice of the new quantum mechanics. As an interesting sidelight to this discovery, the somewhat earlier demonstration of the splitting of silver atoms by Stern and Gerlach did not play a role in the thinking of Goudsmit and Uhlenbeck; that experiment was not even cited in the *Naturwissenschaften* paper (1921). A combination of circumstances, including the erroneous assignment of orbital angular momentum to the silver atom, did not require spin to interpret that experiment. Only later did the existence of spin, as well as the fact that the ground state of silver in reality possessed zero orbital angular momentum, result in its correct interpretation. In fact, the discovery of electron spin grew almost inevitably out of the principal experimental focus of Dutch and German physics, which was the study of optical spectroscopy of relatively simple atomic systems, both with and without the presence of external magnetic fields. Zeeman, Back, Paschen, and others showed that both visible and x-ray spectra were revealing split lines with anomalous magnetic field dependence, instead of the simple spectra predicted from the energy levels of the Bohr model.

Goudsmit's entire career was colored by this early achievement. George Uhlenbeck himself went on to an illustrious career in physics, and the two of them remained close friends throughout their lives. On the basis of this work Goudsmit received his Ph.D. degree from Leiden in 1927. It was at this time that he married Jaantje Logher. They had a daughter, Esther, who is presently a retired professor of biological sciences at the Oakland University, Rochester, Michigan. The Goudsmits were divorced in 1960, after which he remarried, to Irene Bejach.

During the next few years, between his spin paper and the receipt of his Ph.D., Goudsmit continued his work in spectral analysis and dug even further into its rich bounty. Through much of his scientific career his interest in the analysis of atomic spectra remained his dominant focus. He tackled hyperfine structure, the spectroscopic signal attributable to the spin and the magnetic moment of the atomic nucleus. Spectroscopic analysis was at the time the principal means of connecting quantum theory to experimental observation. In addition, once the theory of fine structure—which required electron spin—was under control it could be applied as an indirect but powerful tool for the study of nuclear physics. Precision spectroscopic measurements could yield values of nuclear spins and even rough values of nuclear magnetic moments. This process was finally superseded in the 1930s when the use of radiofrequency resonances studies using atomic beams was invented by I. I. Rabi and others at Columbia University.

At this point, in 1927, the careers of young Goudsmit and his fellow graduate student George Uhlenbeck took a new direction when they were noticed by the eager, farsighted Harrison McAllistor Randall. Randall was Chair of the physics department of the University of Michigan. With Ehrenfest's strong recommendation through an emissary Randall offered both of them faculty positions and with Ehrenfest's encouragement they both accepted. A compelling reason why these two gifted young Europeans were persuaded to leave the flourishing physics culture then prevalent in Europe was the fact that the structure of physics departments at European university was top-down, that is, there were only one or two powerful leaders, the full professors, in each department, with very little turnover in these coveted positions. Young academics had many years of secondary positions, with secondary salaries, to look forward to with no certainty of ever attaining professorships. Despite the lower reputations of American universities their more open career structures and their obvious eagerness to achieve quality were appealing to Goudsmit and Uhlenbeck. Ehrenfest famously expressed the opinion to Goudsmit and Uhlenbeck that the derivative of the state of physics in the United States—which was positive—was more important than its actual state at the time.

Uhlenbeck established himself as a leading theorist of the department, specializing in statistical physics. Goudsmit quickly acquired the gifted Robert F. Bacher—later to become provost of Caltech—as a graduate student and the two of them published an important article in *Physical Review* on the analysis of hyperfine structure in strong magnetic fields. There followed a slew of additional articles on this subject with Bacher and other graduate students as well as one, without coauthors, on the theory of hyperfine structure separations in 1931. During this period, he collaborated with Linus Pauling and Bacher on the books *Structure of Line Spectra* (1930) and *Atomic Energy States* (1933), respectively. He met Pauling while they were both visitors at Niel Bohr's institute in Copenhagen, and they apparently wrote the book without actually having met together during its preparation.[1] The Goudsmit-Bacher book was the first serious effort to tabulate atomic energy levels, reconstructing them from spectroscopic data—no mean feat. This volume was the precursor to the famous Charlotte E. Moore series on atomic energy levels that was later produced at the National Bureau of Standards (now National Institute of Standards and Technology). Thus, before he was 30 years old, Goudsmit had already established himself as an internationally known atomic theorist.

As with any great physicist Goudsmit possessed an inimitable personal style. He was never a deep formal theorist. Rather he always sought ways to more directly link theory with observation. This is most dramatically indicated in the concept of fractional parentage, which he and Bacher cooked up in order to predict energy levels of unknown states of excited atoms and ions in terms of known ones. The method is based on the derivation of linear relations that express the unknown energy in terms of observed energy values of the atom and its ions. They show that the degree of approximation increases with the amount of experimental data available for use in the calculation and also how the best formulas can be obtained for each case. Several tables containing formulas for configurations involving *s* and *p* electrons are given. These are applied to the spectra of carbon, nitrogen, and oxygen, and the energy values so determined are compared with those known from observations. This computational technique was later used by De Shalit, Racah, Talmi, and others to great effect, and in nuclear as well at atomic structure calculations. It was for this reason that Goudsmit was a perfect partner for Uhlenbeck and later for Bacher, both of whom supplied a formal expertise complementing Goudsmit's more intuitive informal style.

The spirit of those days in Ann Arbor is best expressed by Bacher in Goudsmit's obituary, which he wrote years later:

> This was a very happy time for Sam. He was deeply involved in research and was recognized as a leading atomic spectroscopist before receiving his PhD degree at Leiden in 1927. During 1926 he held a Rockefeller Fellowship in Copenhagen, then the center of much of the development of quantum mechanics. He also visited Tübingen to work with Ernst Back who was studying the unusual structure of spectral lines beyond the ordinary multiplet structure and the behavior in strong magnetic fields. Pauli had suggested in 1924 that this hyperfine structure was possible due to the interaction of a nuclear magnetic moment but it was Sam who noted in the beautiful experiments of Zeeman and Back the typical multiplet structure especially when the separations of one of the states was small. This gave a new method to aid in the analysis of atomic spectra and provided examples of the behavior of the hyperfine structure states in strong magnetic fields. Sam considered this interpretation his major accomplishment.

During the first nine years of Goudsmit's residence in Michigan, he published about 25 articles, almost all of them in *Physical Review*, with a few still in Dutch and German journals, with most of these related to hyperfine structure. Goudsmit was among the very first to perceive that precision spectral analysis could be used to determine nuclear spins and magnetic moments. In a heavily cited *Physical Review* article in 1933 he published a summary of these properties for nuclei throughout the periodic table. Around 1936 Goudsmit significantly broadened his interest in nuclear physics, and at the same time parted from being strictly a theorist to participate in several experimental studies of neutron diffusion and scattering. His first (very short, theoretical) paper on this new subject, published alone, was “On the Slowing Down of Neutrons” in *Physical Review* in 1936, followed by an experimental paper with three students, “Diffusion of Slow Neutrons.” His work thereafter in Michigan gradually evolved into theoretical electron scattering studies. He maintained his fundamental style, which was to work in areas where results could be directly compared with experiment.

Goudsmit’s idyllic period at Ann Arbor ended as the Second World War began. He took leave from Michigan and accepted a temporary position at Harvard, where he hoped he would be able to contribute more directly to the growing war effort in the United States, even though its entry into the war was over a year away. Goudsmit was a strong anti-Nazi from the very beginning, and he was eager to participate in the war effort. In 1941 he joined the MIT Radiation Laboratory, which gave him the opportunity to do this more directly. This assignment placed him at the center of one of the most important scientific activities of the war; the Rad Lab was where the American radar research was going on, with the participation of just about the best of those American physicists who were not working on the atomic bomb. The Rad Lab had invented the short-wavelength (10 cm) magnetron, the heart of a new, greatly improved radar system. At some point Goudsmit was detailed to the London Rad Lab office. In one of his oral history recordings he describes how he and a colleague educated an entire roomful of Army and

Air Force brass about its efficacy,[2] a crucial advance that made it possible for bombers to carry a full load of bombs, rather than having to fill bombers with the previously used long-wavelength radar equipment.

A portent of his later career as editor of *Physical Review* was the fact that he was also placed in charge of the Rad Lab document room. This was a perhaps surprisingly important assignment. The Research Laboratory of Electronics (RLE) reports became a primary source of the vast technical information acquired during the war in radar and other areas, including intelligence concerning German radar efforts, that proved invaluable to American physics tooling up to return to basic research after the war.

In May 1944 Goudsmit was tapped for an even more important assignment: scientific head of the Alsos Mission. This was the U.S. Army's effort to go swiftly into Europe as it was being liberated by U.S. and Allied forces in order to discover how the Germans were faring in their efforts to develop atomic weapons. Goudsmit always claimed that he had no idea why he was chosen to lead this crucial effort; in fact, the choice was not only appropriate but was also an extremely wise one. First, Goudsmit personally knew practically every principal physicist in Europe. All of them visited Leiden while Ehrenfest was the professor there and Goudsmit a favored student. Goudsmit had also been the central organizing figure in the famous series of summer schools initiated by Randall at Michigan, where again every major European physicist appeared from time to time, with Goudsmit participating in all these schools. In fact, the star German physicist of all, Werner Heisenberg, actually stayed in Goudsmit's house and they had become good personal friends. In addition, while Goudsmit had already been involved with neutron research—which made him at least knowledgeable in the subject—he had no connection with the U.S. atomic bomb effort through the Manhattan Project. The U.S. Army and General Leslie Groves, the Manhattan Project commanding officer, thought this was a good idea in case Goudsmit was captured by the Germans, since he could give them no bomb information. And, it happened that three months before his selection he had written a letter to Lee A. DuBridge, head of the Rad Lab, in which he stated, "I have very close personal contacts with most of the physicists in Italy, France, Belgium, Holland and even Germany."

Goudsmit possessed a personal quality that turned out to be a perfect match for the job. Throughout his life Goudsmit thought of himself as a problem solver, and indeed he possessed many of the qualities of a gifted detective, as his friend Jonothan Logan later described him. He had a lifetime hobby as an Egyptologist, a perfect outlet for a puzzle solver. He loved being challenged, and here he was handed one of World War II's best challenges. Goudsmit wrote a famous book on this adventure, *Alsos* (1947). This code name means "sacred grove" in Greek—not quite the misleading label that a secret mission should warrant. Goudsmit and his scientific staff had an extraordinary opportunity to examine the German nuclear effort. Often they would arrive at some laboratory within hours of occupation, with physical risk sometimes present. The essence of their discovery was that the Germans, despite a substantial head start in prewar days, had fallen far behind the Manhattan Project effort, and by the time their efforts were foiled by Allies occupation they had not even successfully constructed a working reactor. Even in their last desperate days Heisenberg had only managed to achieve some neutron multiplication in a jerry-rigged pile using unenriched uranium and heavy water, without reaching criticality. This was long after Fermi, in 1942, had already constructed a fully functioning reactor at the University of Chicago. A reader with interest in the subject of Nazi atomic bomb research would best be advised to go directly to the Goudsmit book, fortunately back in print, which offers an extraordinarily detailed picture of European atomic bomb research, as well as a more general appraisal of German physics and physicists.[3]

One of the most moving passages coming out of World War II literature, in my opinion, is Goudsmit's description in the Alsos book of his visit to his childhood home in The Hague, almost too painful to read. On a side trip from his Alsos duties he drove to his parents' apartment, where he had spent his childhood. He found the apartment, unoccupied, in a complete shambles, with some of his own old papers and high school records scattered around. His parents had been sent to a concentration camp and murdered, as he discovered from the orderly records kept by the Nazis. They had missed the opportunity to emigrate to the United States, having received visas just a few days before the German invasion of The Netherlands. Bacher, his old student and lifelong friend, observes in his Goudsmit obituary that "Sam never did recover the very light touch that he had before the war, but gradually he recovered a fair measure of his old buoyancy."

The so-called race for the atomic bomb between Germany and the United States and Britain turned out to be quite one-sided. In his book Goudsmit describes in detail the German effort, which proceeded in fits and starts, hindered by German bureaucracy, Allied bombing, overconfidence, the devastation to German science of the persecution of Jewish scientists and dissenters, and other factors. As for Heisenberg, Goudsmit is fair but not particularly admiring of his role in seeking the bomb. To quote Goudsmit,

> The real brains of the project was Werner Heisenberg. . . But the Führer principle does not work very well in scientific projects, which are essentially collective endeavors and depend on the critical give and take of many minds

and viewpoints. Had Heisenberg considered himself, had he been considered by his colleagues, as less the leader and more the co-worker, the German uranium project might have fared better.

Almost immediately after the dropping of the Hiroshima and Nagasaki bombs, the principal German scientists, Heisenberg included, began to shade the historical record so as to make it appear as though a major reason for the German failure to produce the bomb was the reluctance, if not outright sabotage, on the part of the German scientists to help develop such a weapon for the Nazi regime. Heisenberg himself presented a polite but differing view in a series of articles and letters, to which Goudsmit responded in various venues, including in Alsos.[4] Two books by Robert Jungk and Thomas Powers clearly indicated their authors' belief in a "moral" position by Heisenberg and in fact both suggested overt resistance to the bomb's development on Heisenberg's part. However, in the face of irrefutable evidence to the contrary Jungk (though not Powers) eventually recanted this claim.[5] Finally the play *Copenhagen* by the British playwright Michael Frayn reignited the controversy by again implying a moral motive to Heisenberg. While the Frayn play was an excellent work of fictional drama, its historical accuracy was flawed, with Frayn's implied endorsement of that claim. While Goudsmit, in the light of further information available after the war, did acknowledge several errors in the description of Heisenberg's knowledge in his book, he stuck firmly to his central conclusions, which did not depend on these details. In fact his original conclusions concerning the reasons the Nazis failed in developing the bomb have held up very well. An interesting sidelight of the Alsos affair was the fact that Goudsmit was the person who decided which of the German physicists should be taken to England and interned at Farm Hall for a six-month period, which included time both before and after the Hiroshima and Nagasaki bombs had been dropped. The secretly recorded conversations of these people have served as an invaluable window into their thinking about nuclear weapons.

It has been claimed that Goudsmit's personal tragedy concerning his parents colored his opinions of German atomic research. This is readily refuted by referring to the obituary of Heisenberg written by Goudsmit for the 1976 Year Book of the American Philosophical Society (see Appendix 2), in which he credits Heisenberg with being among the greatest scientists of our era, ranking his contribution to be as "revolutionary as those of Einstein and as profound as those of Bohr." He also states, "He defended his science under dangerous circumstances. He chose to stay in his beloved country even though he was surrounded by hostility. Many of us hoped that he would have been more outspoken in condemning the Nazi regime." Goudsmit believed it was wrong for any scientist, Heisenberg included, to remain as a cooperative citizen of that evil regime, despite Heisenberg's obvious patriotism and personal dislike of Nazi excesses. But the implied criticism quoted above is about as strong a one as he was able to muster. Even so, while Goudsmit and Heisenberg remained civil friends throughout their lives, their early true friendship did not survive the blows of history.

Rather than attempting to summarize the copious volume of articles and books on the Goudsmit-Heisenberg conflict, I refer the reader to some of the more important ones listed in Appendix 2. At least in my opinion the attribution of moral motive to the German failure, and of Heisenberg in particular, to develop the bomb can be comfortably laid to rest.

With the war ended and his Alsos mission completed Goudsmit decided to accept an offer from Northwestern University. But after several years he relocated, to become chair of the Physics Department at the newly created Brookhaven National Laboratory in Upton, Long Island, New York, which had become one of the major centers of large-scale postwar physics research. The worlds of physics and physicists had changed. With the success of the Manhattan Project and the role played by physicists in the development of radar and other critical scientific achievements of World War II the days of "string and sealing wax" physics had passed. Physics became big time, with big machines, high prestige, along with a central role in national defense—all these factors helped make Brookhaven an exciting and important center. Goudsmit fit well into the Brookhaven culture, where fundamental physics, applied physics, and defense physics all coexisted (even though Brookhaven was never one of the most important national defense centers, such as Los Alamos or Livermore). Goudsmit's days of doing pure physics were over. He acquired major administrative responsibilities and not surprisingly morphed into one of the elder statesmen of physics and physics policy, even though he was still only in his late forties. He wrote numerous articles on policy and physics issues, and even for a while served as a consultant to the federal government on cold-war security issues. He was an active organizer and supporter of the Federation of Atomic Scientists, and strongly defended J. Robert Oppenheimer during his security hearings, even though he was not an uncritical admirer of him.

The next phase of Goudsmit's life is inexorably interwoven with the story of the American Physical Society (APS) and in particular its publications. For about half a century APS had been the publisher of the leading American physics journal *The Physical Review*.[6] When its longtime editor at the University of Minnesota, John T. Tate, died in 1950, editorship of the *Physical Review* and its sister journal *Reviews of Modern Physics* was passed on to Goudsmit, along with his associate Simon Pasternack. The editing and production of these journals were transferred to Brookhaven, where in fact all APS scientific publication activities continue to this day.[7] Sam continued first as editor and later when *Physical Review* broke up into specialty sections, its first editor in chief, until his retirement in 1975. During this period of explosive growth in physics activities throughout the world, Sam imprinted his inimitable style on the APS journals. Coincidence or not, during this same period the APS journals became the leading physics publications in the world. This would likely have occurred in any case, but Sam's editing and production styles played no small part in this achievement. All of his qualities—his energy, breadth of interests, creativity, love for detail, curiosity, innate fairness —came into play.

Sam was a very hands-on editor, despite the ever-increasing number of papers he had to deal with. The editorial staff continued to grow, of course, and with the growing burden of submitted papers his job as a line editor gradually changed to that of policy chief. This, however, never stopped him from becoming directly involved in editorial decisions on papers of particular significance.[8] At one point he even published a small tract on improper handling of data. Sam was famous for his pithy editorials, which appeared in the journals from time to time. Here is one example. In connection with an attempt to defuse author quarrels related to priority in publication, he recounts a well-known story about Niels Bohr, which goes something like this: An American scientist once visited the offices of the great Nobel Prize-winning physicist Bohr in Copenhagen and was amazed to find a horseshoe nailed to the wall over his desk. The American said with a nervous laugh, "Surely you don't believe that a horseshoe will bring you good luck, do you, Professor Bohr?" Bohr replied, chuckling, "I believe no such thing, my good friend. Not at all. I am scarcely likely to believe in such foolish nonsense. However, I am told that a horseshoe will bring you good luck whether you believe in it or not!" In an editorial in Physical Review (25[1970]:419) Goudsmit states, "In my study hangs a fine old horseshoe, which I found in an abandoned Western ghost town. I don't believe in superstitions, but it is supposed to work even for a nonbeliever." Then he adds in a footnote, "For historians . . . I passed [this story] on to Niels Bohr in 1954 when he visited Brookhaven. It is now known as 'Bohr's story.'" W. Heisenberg in his book *Der Teil und das Ganze* incorrectly has Bohr telling it already in 1927. Sam's point was that the author should be delighted that someone else had co-opted his priority, since this proved how important his work had been.

Among his many achievements was the founding, under his leadership, of *Physical Review Letters* in 1958. It is difficult to believe that formidable journal has not been with us forever, but in fact it was a creative solution to the ongoing problem of dealing with singularly important advances in a timely and fair manner. Hitherto these papers appeared scattered across the several Physical Review sections as "Letters." To make the new journal more readable Goudsmit developed a slim format so that the whole range of physics specialties could be included. Using in-house production with new typewriter composition methods that he himself helped to design, the new journal achieved unprecedented production speed. It turned out that Physical Review Letters was such a success that it became the first of many such rapid publication journals internationally. Its success, however, created an entirely new set of problems resulting from authors' eagerness to have their papers accepted in this most highly desirable new medium. Many of Sam's editorials addressed this latter problem, although one must state that he never succeeded in calming authors' need to publish in what had perhaps inadvertently become the world's most prestigious physics journal.

Upon his retirement he produced yet another editorial titled "Swan Song," in which he states,

> According to the Constitution and Bylaws of the American Physical Society I will have reached statutory senility on the day of the next Council meeting . . . I am expected to make a few profound statements about changes which occurred in physics over the years. I am also expected to predict the future, but I refuse to do that in print.

Sam had taken a strong liking to the Western desert, and upon his retirement from APS and Brookhaven he accepted a position as a distinguished visiting professor of physics at the University of Nevada at Reno. There he gave undergraduate lectures and as usual involved himself deeply in departmental activities. He is still remembered there by an annual Goudsmit lecture series and a venue called the "Goudsmit Room."

Up until now I have neglected to describe his extracurricular interests. Throughout his life he was interested in Egyptology in particular, and although he certainly considered himself an amateur he lectured on the subject and published a number of articles in archeological journals. It was a perfect release for the detective aspect of his character.

In conclusion I again quote from the final editorial about Sam from Physical Review Letters in 1978:

> Sam died on 4 December from a heart attack while he was on the University of Nevada campus . . . We last saw him at a meeting of the Publications Committee of The American Physical Society held in New York on 16 November. Sam was then, as always, warm and witty, sardonic and wise, and above all, enthusiastic—enthusiastic about the prospects of the future of the publications he shepherded so long and enthusiastic about the teaching he was doing at the University of Nevada.

Possessing a piercing and critical intelligence, a warm personality, and energy and strength of character, Sam left behind many monuments: in science, especially in atomic physics, in government service during and after World War II, in administration through his chairmanship of the Brookhaven National Laboratory Physics Department in the early days of that laboratory, and in publications through his management of the main journal of the American Physical Society, the *Physical Review*. Though few men have contributed more than Sam to the shape of the world physicists know today, the private memories many of us have of Sam's kindness and consideration, all salted with his bluff wit, are not less important than his more concrete achievements. —Signed by the editors of Physical Review Letters (42[1979]:1): R. K. Adair, G. L. Trigg, and G. L. K. Wells.

The rich and varied life of Samuel Abraham Goudsmit has been chronicled many times and in many places, although no complete book-length biography of him exists. Apart from the obvious encyclopedia, newspaper, and magazine articles and obituaries, there are several particular informative ones by himself and several of his friends and colleagues. I list some of these in Appendix 2 of this memoir. The author thanks Sam's daughter Esther Goudsmit for her help in collecting material for this article and for a careful reading of the manuscript. I also thank the Center for History of Physics at the American Institute of Physics for its cooperation in allowing me full access to the Goudsmit collection.

HONORS AND AWARDS

My opinion of such medals and honorary science degrees which I have collected is that they are merely a sign of old age. The only real ones were those I got for my exploits during WWII.

—Samuel Abraham Goudsmit
December 5, 1977

1946	Medal of Freedom
1947	Member, National Academy of Sciences
1948	Order of the British Empire
1954	Research Corporation Award
1958	Honorary D.Sc., Case Institute
1962	Half Moon Trophy Award, Netherlands Club of New York
	Honorary member, Sigma Pi Sigma
1964	Max Planck Medal, German Physical Society
1972	Honorary D.Sc., Utah State University, University of Chicago
1974	Karl T. Compton Award for Distinguished Statesmanship in Science, American Institute of Physics
1975	Honorary D.Sc., Northwestern University
1977	National Medal of Science
	Commander of the Order of Orange-Nassau (Netherlands)

MEMBERSHIPS

American Nuclear Society
American Physical Society
American Philosophical Society
American Academy of Arts and Sciences
Correspondent, Royal Netherlands Academy of Science

NOTES

1. In a handwritten letter to Goudsmit dated November 16, 1927, Pauling states, "You remember that in Copenhagen you spoke to me saying that you would like to publish your thesis in English . . . perhaps you would be interested in a proposal I shall make you. I am writing an elementary discussion of spectra for a book . . . and I have found your thesis very clear and satisfactory. I should like to translate it, if you will consent . . . I should like to rewrite is and expand it to about twice the size." The complete four page letter can be seen at *osulibrary.oregonstate.edu/specialcollections/* and then searching for Goudsmit. See also the Goudsmit typewritten response only a few days later.

2. Claremont Graduate School Oral History Program. See Appendix 1.

3. Another superb source for this and other German science activities before and during the war is the book *Uncertainty* by David C. Cassidy (W. H. Freeman & Co., 1991), which is nominally the biography of Werner Heisenberg but is also an invaluable source for much of European physics during the early days of quantum mechanics and during World War II.

4. See Appendix 2 for a summary of some important references regarding the interchanges between Goudsmit and Heisenberg.

5. See A. Pais. *Niels Bohr's Times*, p. 484. New York: Oxford University Press, 1991.

6. See *A Memoir of the Physical Review* by Paul Hartman (published by APS and the American Institute of Physics), 1994, for a history of the Physical Review, particularly during its first half-century.

7. Actually the publication office now occupies its own substantial building right down the road from Brookhaven.

8. The story of Goudsmit's involvement with the first laser papers illustrates how even great editors can make mistakes. At one point after the invention of the maser, *Physics Review Letters* (PRL) was flooded with maser papers, and Goudsmit made a policy of no longer accepting such papers in PRL as opposed to *Physical Review.* Unfortunately, T. H. Maiman submitted a paper to PRL on the "optical maser"—in other words, the first laser. The paper was rejected by PRL, and subsequently immediately published in *Nature.* For a complete and fair description of this and other pioneering laser papers in PRL, see an very interesting report of an interview with Arthur Schalow at *http://content.cdlib.org/dynaxml/servlet/dynaXML?docId=kt5b69n7k2&doc.view=entire_text.*

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Alsos. New York: Henry Schuman. (Reissued 1996 with new introduction by David Cassidy, American Institute of Physics.)

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It might as well be spin. *Phys. Today* 29(6):40-43.

APPENDIX 1

THE SAMUEL A. GOUDSMIT PAPERS, 1921-1979

This is a treasure trove of all things Goudsmit. Originally scattered at various venues it has almost all been unified at the American Institute of Physics, Center for History of Physics (AIP-CHP) at One Physics Ellipse, College Park, Md. 20740. The finding aid was encoded for online access with a grant from the National Endowment of the Humanities. See *www.aip.org/history/ead/20000092_content.html* for the 30-page finding aid.

As Goudsmit described himself, he was a "pack rat," collecting correspondence (often two-way), papers, souvenirs, Alsos material (some still marked secret), many of his curricular and extracurricular writing, Egyptology material, as well as innumerable audiovisual material and memorabilia. The AIP-CHP is thinking of digitizing the entire collection, subject to acquiring funding for the project. Dr. Weart, the director of CHP, states that this collection is the most popular of all their archives.

APPENDIX 2

SOME GOUDSMIT SOURCES

- "Samuel A. Goudsmit—An Obituary" by his first student and later colleague Robert F Bacher. May 22, 1979. Available from the Archives of the California Institute of Technology.
- "Goudsmit, Bohr, and Heisenberg," A talk by Rudy Paul Lidner at the Michigan Center for Theoretical Physics, November 27, 2001, describing the interactions between Goudsmit and Heisenberg, particularly relating to the famous September 16, 1941, meeting between Heisenberg and Bohr in Copenhagen. Available at *http://www.personal.umich.edu/~rpl/Goudsmitlecture.htm.*
- "The Discovery of the Electron Spin" by S. A. Goudsmit. In his own words. A talk delivered at a convocation of the Dutch Physical Society in April 1971. A perfect place to capture his inimitable style, in which he lays out the story of the discovery of spin, within the context of Dutch physics at the time.
- Goudsmit editorials in *Phys. Rev. Lett.*: "Bias" (5[1970]:419-420); "Swan Song" (33[1974]:991-992); and many others accessible through the American Physical Society PROLA database. See especially "Samuel A. Goudsmit (1902-1978)," an obituary by R. K. Adair, G. L. Trigg, G. L. Wells (42[1979]:1).
- "Werner Heisenberg (1901-1976)," an obituary of Heisenberg by Goudsmit for the *Yearbk. Am. Philos. Soc.*, 1976, pp. 74-80. A sympathetic appraisal of Heisenberg's life with only muted criticism of his behavior during the Nazi period.
- *New York Times* obituary by Walter Sullivan, Dec. 6, 1978, p. B6.
- Transcript of Goudsmit's oral history from an interview held at Claremont Graduate University in 1976. This is a 131-page transcript, with an index, of an interview by four members of the Harvey Mudd College of Science and Engineering, Claremont Graduate School, including Vladimir Rojansky; G. D. Bell, physics chair; J. D. Rae, history professor; and E. H. Douglass, director of the Oral History Program of the Claremont Graduate School. Sam talks freely about his many careers, does not stint on offering opinions, and in general presents a valuable insight into his personality, physics, and life's views. A copy can be obtained for a modest fee from the Oral History Office, Claremont University, 121 E. Tenth St., Claremont, Calif. 91711-3911.

- Jeremy Bernstein, *Hitler's Uranium Club—the Secret Recordings at Farm Hall, New York,* Springer-Verlag, 2001. The full Farm Hall transcripts plus perceptive comments by Bernstein. Alternatively, Charles Frank, *Operation Epsilon: The Farm Hall Transcripts,* Institute of Physics Publishing, 1993.
- "A Farewell to String and Sealing Wax," a two-part profile of Goudsmit in the *New Yorker* magazine by Daniel Lang, Nov. 7 and 14, 1953.

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