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Hans Bethe, Prober of Sunlight and Atomic Energy, Dies at 98

By WILLIAM J. BROAD

Hans A. Bethe, who discovered the violent reactions behind sunlight, helped devise the atom bomb and eventually cried out against the military excesses of the cold war, died late Sunday. He was 98, among the last of the giants who inaugurated the nuclear age.

His death was announced by Cornell University, where he worked and taught for 70 years. A spokesman said he died quietly at home.

Since the war years at Los Alamos, N.M., Dr. Bethe had lived in Ithaca, N.Y., an unpretentious man of uncommon gifts. His students called him Hans and admired his muddy shoes as much as the way he explained how certain kinds of stars shine. For number crunching, in lieu of calculators, he relied on a slide rule, its case battered. "For the things I do," he remarked a few years ago, "it's accurate enough."

For nearly eight decades, Dr. Bethe (pronounced BAY-tah) pioneered some of the most esoteric realms of physics and astrophysics, politics and armaments, long advising the federal government and in time emerging as the science community's liberal conscience.

During the war, he led the theoreticians who devised the atom bomb and for decades afterwards fought against many new arms proposals. His wife, Rose, often discussed moral questions with him and, by all accounts, helped him decide what was right and wrong.

Dr. Bethe fled Europe for the United States in the 1930's and quickly became a star of science. As a physicist, he made discoveries in the world of tiny particles described by quantum mechanics and the whorls of time and space envisioned by relativity theory. He did so into his mid-90's, astonishing colleagues with his continuing vigor and insight.

In a 1938 paper, he explained one of the ways in which the sun and similar stars fuse hydrogen into helium, releasing bursts of energy and ultimately light. That work helped establish his reputation as the father of nuclear astrophysics, and nearly 30 years later, in 1967, earned him the Nobel Prize in Physics. In all, he published more than 300 scientific and technical papers, many of them originally classified secret.

Politically, Dr. Bethe was the liberal counterpoint (and proud of it) to Edward Teller, the Hungarian physicist and strong conservative who played a dominant role in developing the hydrogen bomb. It brought to earth a more furious version of the fusion reactions in stars, and Dr. Bethe opposed its development as immoral. For more than a half-century, he championed many forms of arms control and nuclear disarmament, becoming a hero of the liberal intelligentsia.

His wife called him a dove, Dr. Bethe once told an interviewer, adding his own qualifier: "A tough dove." His gentle manner hid an iron will and mind that had few hesitations about identifying what he saw as error, hypocrisy or danger. "His sense of duty toward society is so deeply ingrained that he isn't even aware of its being a sacrifice," a close colleague, Victor F. Weisskopf, once remarked.

No Regrets on Bomb

In a 1997 interview in his Cornell office, at age 90, Dr. Bethe said he had no regrets about his role in inventing the atom bomb, done amid worries about the Nazis' getting it first and conquering the world. But as the most senior of the living scientists who initiated the atomic age, he urged the United States to renounce all research on nuclear arms and called on scientists everywhere to do likewise.

His ultimate dream, he said, his blue eyes calm, was for nations to cut their nuclear arsenals to a few hundred arms or less. "Then," added Dr. Bethe, a survivor of Hitler and Mussolini, "even if statesmen go crazy again, as they used to be, the use of these weapons will not destroy civilization."

Throughout life, he remained a staunch advocate of nuclear power, defending it as an answer to inevitable fossil-fuel shortages.

Dr. Bethe was the last of the scientific greats who led the Manhattan Project to build a bomb and thus initiated the nuclear era, outliving not only Dr. Teller but Enrico Fermi and J. Robert Oppenheimer, the scientific head of wartime Los Alamos. "He was one of Oppenheimer's first recruits," said Robert S. Norris, author of "Racing for the Bomb" (Steerforth Press, 2002), "and was among the last survivors of that extraordinary story."

Mr. Norris added that Dr. Bethe was "the almost perfect expression" of the scientist-activist, driven by a sense of responsibly for his own atomic breakthroughs and those of his physicist colleagues. "He saw his role as to educate the public and the policymakers about the new dangers and help figure out ways to control them," Mr. Norris commented.

A biographer, Silvan S. Schweber of Brandeis University, author of "In the Shadow of the Bomb" (Princeton, 2000), said he despaired of mastering Dr. Bethe's archive of letters, papers and documents. Later, he feared that he would need "three fat volumes" to tell the physicist's story. He described Dr. Bethe as a moralist who took stands in defense of universities, democracy and society. What gave him the courage to do so, he added, was self confidence, a strong personality and the support of the community of friends and scientists he nurtured for nearly seven decades at Cornell.

Richard Rhodes, who wrote of Dr. Bethe in "The Making of the Atomic Bomb" (Simon & Schuster, 1986), remarked on his sunny disposition despite his long struggle with nuclear dilemmas. "He seemed so calm and, later in life, so serene," Mr. Rhodes said. "That's interesting because he, more than any other leading figure of the Manhattan Project, agonized over his participation, first in the bomb itself and then in thermonuclear research" to see if a hydrogen bomb was possible.

He was not a tragic figure wracked by guilt - the fate of some who came to regret their bomb labors - but a man famous for his indefatigable appetite. His lean body could boom with laughter. He loved to ski and climb mountains with colleagues. Students learned to rely on his patience and readiness to help, be it with research or personal problems.

Freeman Dyson, a mathematician at the Institute for Advanced Study in Princeton, recalled meeting Dr. Bethe at Cornell in 1947. "The thing that impressed me the most," he said, "was that he had very muddy shoes and all the students called him Hans. So he was just the opposite of a European professor. That was part of his greatness. He was totally unpretentious and never tried to be bigger than he was."

Dr. Bethe, he added, "always had lunch with the students and had a real concern for the teaching and all the students he was responsible for. He had a wonderful gift for finding the right problem for them, not too difficult and not too easy."

Dr. Bethe's long life embodied a deep faith not in the ultimate authority of science but of people and the human spirit - a surprising stance for a man often viewed as one of the field's high priests. He understood its limits. His personal philosophy seemed deceptively simple: Science and technology, while good friends of great importance, cannot save humanity. Instead, he taught that only humane reasoning and the struggle to foster just human relationships would keep civilization from using the accomplishments of science to destroy itself.

Hans Albrecht Bethe was born on July 2, 1906, in Strasbourg, Alsace-Lorraine, to a family of modest means. His father, a physiologist at the University of Strasbourg, was a Protestant and his mother Jewish. He was their only child. A the frail youth, he showed an early genius for mathematics, which his father discouraged, not wanting his son to get ahead of his peers. The precocious boy took to secretly reading his father's books on trigonometry and calculus.

Dr. Bethe once said he grew up in the solace of "numbers and fairy tales." The family moved to Frankfurt, where his father founded a physiology department at the new university. At the nearby gymnasium, his son studied Greek and Latin, French and English, but excelled at math and physics, deciding he wanted to do both.

At the University of Munich, Dr. Bethe studied with Arnold Sommerfeld, one of the day's leading theoretical physicists. His teacher bristled with excitement for modern physics, and the student was soon lost to anything else. In 1928, Dr. Bethe received his Ph.D., graduating summa cum laude, having already contributed to the fledgling science of quantum mechanics. The next year he worked for Paul P. Ewald, a noted physicist in Stuttgart, and befriended his family, often visiting and having dinner.

At times, Dr. Bethe took the older Ewald children on Sunday walks, including Rose, his future wife. After stints at several universities, he came into conflict with the Nazi race laws and fled Germany in 1933. For two years he taught in England and then came to Cornell, where he remained all his academic life.

While lecturing at Duke University in 1937, he bumped into Rose Ewald, who had emigrated and was a student there. The two fell in love.

'Bethe's Bible'

At Cornell, Dr. Bethe wrote a series of brilliant papers that culminated in the 1938 treatise, "Energy Production in Stars." It set forth the first and only explanation of stellar energy that explained all the known facts - essentially why stars like the sun burn for billions of years. His talents were synthetic as well as analytic, as evidenced by his production of a wealth of incisive review articles that became required reading for generations of physicists. Known as "Bethe's bible," they, like much else he did, mirrored his precision, thoroughness and extraordinary powers of concentration.

The world - and his world in particular - changed forever in 1938 when German scientists discovered that the atom could be split in two in a burst of atomic energy, starting quiet deliberations around the globe into the practicality of chain reactions and a bomb. In America, Dr. Bethe discussed the matter with Dr. Teller, another refugee from the Nazis. The two were close friends. In New Rochelle, N.Y., Dr. Teller was one of the few guests invited in September 1939 when Dr. Bethe and Rose were married.

Dr. Bethe's reputation grew with the war effort. In 1940, Time magazine called him "one of Nazi Germany's greatest gifts to the United States." He was helping advance radar at the Massachusetts Institute of Technology when an atomic recruiter came to call, meeting him conspiratorially in Harvard Yard. In 1942, during a walk in the mountains of Yosemite, his wife asked him "to consider carefully" if he wanted to continue assessing the feasibility of nuclear arms, Dr. Bethe told Jeremy Bernstein, author of "Hans Bethe, Prophet of Energy" (Basic Books, 1979).

Worried that Nazi Germany wanted such weapons, he decided that he did. In 1943, he was named the first director of the theoretical division at Los Alamos, the secret laboratory in the mountains of New Mexico where thousands of scientists, technicians and military personnel were gathering to see if a nuclear bomb was indeed possible. Behind rows of barbed wire, he coaxed some of world's brightest and most idiosyncratic experts to work hard on how to unlock the atom. In typical fashion, he bore down on the problems like a battleship, studying them carefully and then crushing them.

Colleagues often balked. "No, no, you're crazy!" Richard Feynman, a young scientist who eventually gained fame as an eccentric genius, protested one day. But Dr. Bethe plowed ahead, proving his idea exactly right. At Los Alamos, Dr. Bethe's group calculated such things as how much plutonium it would take to build an atom bomb, and whether the detonation would ignite the atmosphere and destroy the earth.

The bomb's horrors became a turning point for Dr. Bethe. After the destruction of Hiroshima and Nagasaki, he devoted himself to trying to stop the weapon's "own impulse," as he put it. While retaining links to the government and Los Alamos, he helped lead the corps of atomic scientists who, in an unprecedented wave, left secluded laboratories to plead before Congress and the American public for nuclear restraint.

He also plunged back into academic life at Cornell, educating a new generation of physicists. He recruited Dr. Feynman, his Los Alamos protégé, and helped him develop quantum electrodynamics, an advanced theory for which Dr. Feynman eventually shared the Nobel Prize.

In April 1950, Dr. Bethe wrote a provocative article in Scientific American arguing against development of the hydrogen bomb, an advance then looming. He had concluded, after discussions with his wife and colleagues, that it had little military use and was primarily a weapon for incinerating civilians in large cities. "We must save humanity from this ultimate disaster," he wrote. "And we must break the habit, which seems to have taken hold of this nation, of considering every weapon as just another piece of machinery and a fair means to win our struggle with the U.S.S.R."

By contrast, Dr. Teller lobbied hard for the superbomb, as it was called. Dr. Bethe worked on it too, hoping to prove the idea impossible and considering his work a hedge against the possibility that the Soviets might get it first. In 1952, a blinding flash of light marked the detonation of the world's first hydrogen bomb, its power roughly 1,000 times greater than the weapon that destroyed Hiroshima.

During the cold war, Dr. Bethe and Dr. Teller went from increasingly cool friends to bitter foes. The breaking

point came in 1954 - at the height of the McCarthy era - over the government's push to remove the security clearance of Dr. Oppenheimer, then the top scientific adviser to the Atomic Energy Commission and a man who probably held more nuclear secrets in his head than any other American.

One charge was that Dr. Oppenheimer had argued against a crash program for H-bomb development. Another was that he had Communist ties. In Washington, Dr. Bethe and his wife spent an evening trying to persuade Dr. Teller to testify in favor of Dr. Oppenheimer - to no avail. At a secret hearing, Dr. Bethe defended his former boss, and Dr. Teller strongly faulted Dr. Oppenheimer's judgment. His clearance was revoked, and he quickly fell from power.

Dr. Bethe later wrote a long article charging that Dr. Teller, not Dr. Oppenheimer, had hindered the nation's pursuit of the superbomb for years because of mathematical errors. It was only after the size of Teller's mistakes became apparent, Dr. Bethe wrote, that Dr. Teller and his colleagues were forced to find the right way to solve the problem. The article, written in 1954, was quickly stamped top secret and only declassified three decades later.

Despite his fears of an unfettered arms race, Dr. Bethe continued to consult for the government and on occasion to help make weapons. In 1955, he perfected a general theory of ablation that was applied to the construction of warheads that could withstand the searing heat of re-entry through the earth's atmosphere. His idea helped beget the intercontinental ballistic missile.

Increasingly, he also sought ways to slow the nuclear arms race, winning new influence for his ideas in Washington. As a member of the President's Science Advisory Committee, starting in 1956, he became a driving force behind the world's first and most successful arms control pact, the 1963 Limited Test Ban Treaty, which confined nuclear tests beneath the earth.

In usual fashion, Dr. Teller fought it all the way. Dr. Bethe saw the treaty as a bold step toward disarmament and a way to end the rain of radioactive fallout that had increased people's risk of cancer and birth defects. "Very good. Very right," he remarked on the occasion of its signing, visibly moved.

His influence soaring, Dr. Bethe in 1967 was awarded the Nobel Prize for his explanation of how the stars shine. A 1968 profile by the journalist Lee Edison described Dr. Bethe as "a tall, spare man with a deceptively distracted look."

"His graying hair seems permanently electrified; his shoes are scuffed, and his tie seems to have been studiously arranged to miss his collar button," Mr. Edison wrote. "He listens attentively, nodding his head as if in agreement, but - as devastated colleagues and adversaries have discovered - this habit is far from a sign of agreement. His 'yes, yes, yes' is rather a signal that his mental apparatus is receiving. What he does with the input is another matter."

In the late 1960's and early 1970's Dr. Bethe lent his growing prestige to fight the government's plans to deploy antimissile weapons. Having studied the issue for President Dwight D. Eisenhower, he was convinced that all such systems could be easily defeated. It was just too easy, he held, for an adversary to make decoys and other countermeasures that offensive missiles would jettison to outwit defensive arms. And while militarily futile, he argued, antimissile arms would succeed extremely well at adding costly new spirals to the arms race as each side struggled for advantage.

Opposed by Teller

As before, Dr. Bethe found himself strongly opposed by Dr. Teller, who this time wanted to shield America from the hydrogen bombs that adversaries had learned how to make. In 1975, at a cost of some $6 billion, the government switched on a limited antimissile system that was soon abandoned because of its ineffectiveness.

In the 1970's, after the Arab oil embargo started a global economic crisis, Dr. Bethe threw himself into championing new ways to produce energy. In articles, speeches and Congressional hearings, he argued that the dangers of nuclear reactors were small compared with many other risks judged to be socially acceptable. During this period, Dr. Bethe and Dr. Teller, both firm advocates of nuclear power, became somewhat closer, "although not with the intimacy of the old days," Dr. Bethe recalled.

He formally retired from Cornell in the summer of 1975. But that did little to slow his activity. In the 1980's, with the arrival of the Reagan administration, Dr. Bethe again found himself the elder spokesman of scientists opposed to unfettered development of nuclear arms. And his relations with Dr. Teller again began to cool. The Pentagon, he said in an article, "proposes to address all threats - real and imagined - by raising the ante. It refuses to recognize that our worst nightmares can be laid to rest only by constraints on technology."

With passion, he fought President Ronald Reagan's proposed shield against enemy missiles, known popularly as Star Wars. It again pitted him against Dr. Teller, in what became their last battle. In February 1983, Dr. Teller tried to win over Dr. Bethe by revealing the secret details of what he considered the ultimate technical fix - the X-ray laser, powered by a nuclear bomb. It would emit powerful beams to smash Soviet warheads before consuming itself in ball of nuclear fire, an H-bomb to destroy H-bombs. "You have a splendid idea," said Dr. Bethe, complimenting Dr. Teller on its physics. But he soon led X-ray laser opposition, arguing that an enemy could easily outwit the exotic weapon.

"We need to try to understand the other fellow and negotiate and try to come to some agreement about the common danger," Dr. Bethe said after his Teller meeting. "That is what's been forgotten. The solution can only be political. It would be terribly comfortable for the president and the secretary of defense if there was a technical solution. But there isn't any."

Ultimately, the government sided with Dr. Bethe, forgoing antimissile deployments in the 1980's and 1990's, a decision the Bush administration has now reversed. In his memoirs in 2001, Dr. Teller accused Dr. Bethe of letting his political views color his technical judgment. Dr. Teller died in 2003.

Despite the political activism that marked his later life, Dr. Bethe never abandoned his first love - science. With what might be seen as poetic finesse, he turned his attention to the question of why old stars can suddenly explode with the brilliance of an entire galaxy. An average star like the sun dies quietly. But larger ones can die violently, though no one is quite sure why. "They go on a rampage," Dr. Bethe said with a smile, the blackboard behind him filled with equations. "In a year they emit as much energy as the sun does in 10 billion years of history. Why does this happen?"

At the start, he said, the central part of a star exhausts its fuel supply, collapsing so fast that the outside of the star stays uninvolved. The small core then bounces back. "The question we are studying," he said, "is whether that shock wave is strong enough to go all the way through the star and to expel essentially all its outside, because that is what is observed in supernovas."

In addition to his wife, Dr. Bethe is survived by two children, Henry, of Ithaca, and Monica, who lives near Kyoto, Japan, and three grandchildren.

In 1995, many of Dr. Bethe's colleagues gathered to mark his 60th year at Cornell with a two-day tribute. "If you know his work," commented John Bahcall, an astrophysicist at the Institute for Advanced Study, "you might be inclined to think he is really several people, all of whom are engaged in a conspiracy to sign their work with the same name."

Alan Lightman, a physicist and author at the Massachusetts Institute of Technology, recalled attending a meeting with Dr. Bethe in October 1997, after the celebrated physicist had turned 91. He expected reminiscences. But Dr. Bethe, after tottering up to the podium, surprised him. "It was a paper on astrophysics that he had just published," Dr. Lightman recalled. "And it was good."

Dr. Schweber of Brandeis University, a physicist and historian, said Dr. Bethe achieved a life of professional and personal fulfillment because he learned the redemptive power of love, of serving family and friends, students and society. Dr. Bethe's élan seemed to confirm that judgment. "I am a very happy person," he said with a relaxed smile a few years ago. "I wouldn't want to change what I did."