In Memoriam: Hans Bethe (1906-2005)

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Hans Bethe, who died on March 6 at the age of 98, was exemplary as a scientist; a citizen-advocate seeking to stem the arms race; and an individual of warmth, generosity, tenacity, and modest habits.

Bethe made major contributions to several areas of physics during his academic career. He earned a Nobel Prize for his 1939 research into how the sun generates its energy by converting hydrogen to helium using carbon as a nuclear catalyst. A few years later, he made central contributions to the secret U.S. World War II nuclear-weapon development program (the “Manhattan Project”).

As did some other talented physicist-refugees from Europe, Bethe joined the Manhattan Project out of fear that Nazi Germany might be developing a nuclear bomb. After contributing to the development of radar at the wartime MIT Radiation Laboratory, Bethe moved to Los Alamos where he was chosen to lead the effort to assess mathematically the explosive properties of the evolving designs of the Hiroshima and Nagasaki bombs. Bethe was universally respected in the fractious physics community, and his calculations were definitive. For example, when Edward Teller raised the concern in 1942 that a nuclear explosion might ignite a fusion chain reaction in the atmosphere or ocean, Bethe showed clearly that this was impossible.[1]

At the end of World War II, Bethe returned to Cornell and became the inspiring figure at the core of a first-rate physics department. During that period, younger members of his group included Richard Feynman and Freeman Dyson. Both made central contributions to the development of the quantum field theory of electromagnetism and are well known for their observations on technology and life. At Cornell as at Los Alamos, Bethe showed the sweetness and generosity of character that was his personal hallmark. He always had time for younger physicists, and one always left a session with him encouraged.

After the war, with the veil of secrecy partially lifted, Bethe began to engage in public commentary; he had long provided advice to the government on nuclear weapons policy. In December 1945, he met in Washington with other former Manhattan Project scientists to found the Federation of American Scientists to urge international control of nuclear energy and “to disseminate those facts necessary for intelligent conclusions concerning the social implications of new knowledge in science.”[2] Over the following decades, Bethe became the most respected of the scientists explaining the technical facts to the public, especially in a series of Scientific American articles written at crucial junctures. The issues with which he was most engaged were:

• The decision to develop the hydrogen bomb in 1950;

• The global campaign in the late 1950s and early 1960s to end nuclear testing;

• The effort over two decades to prevent a destabilizing offensive-defensive arms race.
The Hydrogen Bomb Decision

With some other scientific leaders of the World War II bomb project, including the members of the General Advisory Committee of the Atomic Energy Commission, Bethe advised as an insider against a crash program to develop a hydrogen bomb as a response to the first Soviet nuclear test in August 1949. President Harry Truman rejected this advice and announced his decision to go ahead on January 31, 1950. After the announcement, Bethe used the pages of Scientific American to explain to the American public his fundamental objection to such a weapon:

I believe the most important question is the moral one: Can we, who have always insisted on morality and human decency between nations as well as inside our own country, introduce this weapon of total annihilation into the world? The usual argument, heard in the frantic week before the president’s decision and frequently since, is that we are fighting against a country which denies all the human values we cherish, and that any weapon, however terrible, must be used to prevent that country and its creed from dominating the world. It is argued that it would be better for us to lose our lives than our liberty; and with this view I personally agree. But I believe that this is not the choice facing us here; I believe that in a war fought with hydrogen bombs we would lose not only many lives but all our liberties and human values as well. [3]

Having lost the debate, Bethe returned to Los Alamos, however, as a consultant and, after failing to prove that it would be infeasible to build a thermonuclear bomb, contributed to the design effort. Indeed, following the proposal by Teller and Stanislaw Ulam in March 1951 that the X-ray radiation from a fission explosion could be used to implode and ignite fusion fuel, Bethe led the theoretical program to develop thermonuclear weapons, as he had done with the fission weapon. Bethe later explained that, "[i]f I didn't work on the bomb, somebody else would—and I had the thought that if I were around Los Alamos, I might still be a force for disarmament. It seemed quite logical. But sometimes I wish I were more consistent an idealist." [4]

Teller, by contrast, had been obsessed with the need to develop the hydrogen bomb ever since Enrico Fermi suggested the possibility to him in 1941. [5] After his dream was finally realized, Teller was lionized by the right as “the father of the H-bomb” and became a leading proponent of the need to stay ahead of the Soviets in the arms race and for the deployment of ballistic missile defenses. Teller and Bethe, once close friends, were fated to be on opposite sides of arms control debates for the rest of their lives. Teller died in September 2003 at the age of 95.

The Test Ban

The international campaign for a nuclear test ban began in 1954 after a U.S. hydrogen bomb test showered a Japanese fishing boat, The Lucky Dragon, with radioactive fallout that sickened the crew and ultimately led to one death. Bethe was able to galvanize White House consideration of the issue in 1957 as a member of President Dwight Eisenhower’s new Science Advisory Committee. Eisenhower had created the panel after the Soviet Union shocked Washington by launching the first artificial earth satellite. Following Bethe's suggestion, an interagency panel was set up under his chairmanship to assess the verifiability of a test ban and whether a test ban would benefit the United States. The panel came up with the first design for a verification system, laying the basis for an international conference of experts in 1958 in which Bethe participated. The conference agreed on a seismic system consisting of 180 stations and concluded that underground tests with yields above five kilotons could be detected. [6]

The verification system was torpedoed, however, by an ingenious evasion approach invented by Teller and colleagues, who argued that the Soviet Union would be able to build and conceal underground spherical cavities 1,000 feet in diameter to muffle underground nuclear explosions up to 300 kilotons in yield. On-site inspections therefore would be required to distinguish muffled underground explosions from small earthquakes. Ultimately, the United States insisted on the right to have more on-site inspections annually than the Soviet Union was willing to accept, and the result was that only a Partial Test Ban Treaty could be achieved in 1963, banning nuclear tests everywhere except underground. [7] Powerful political forces in both countries were not willing to accept the obvious compromise.
Missile Defense
Long before Sputnik demonstrated the feasibility of intercontinental ballistic missiles, the U.S. military began to propose systems to shoot them down as a complement to the extensive continental air defense that had already been deployed against Soviet bombers. The president’s science advisers showed the inadequacies of one design after another until, in 1967, Richard Nixon announced that he would make a campaign issue out of the fact that President Lyndon B. Johnson had not deployed a missile defense. Johnson responded by ordering the deployment of a “thin” missile defense called “Sentinel,” nominally designed to defend against the missiles that China was then developing (but only tested 11 years later).

The Pentagon erred, however, when it decided to site nuclear-armed anti-missile rockets in the suburbs of major U.S. cities, including Chicago, Boston, and Seattle. Instead of accepting the protection gratefully, the suburbs were alarmed by the possibility that one of the nearby nuclear warheads might explode accidentally and rose up in an early manifestation of the “not in my backyard” phenomenon. The ruckus created an audience in Congress for arguments against the defense system.

Fortunately, Bethe had already co-authored an article explaining how any country that could develop ICBMs could also neutralize the proposed system by, for example, adding decoys to their payloads that would overwhelm the defense.[8] This paper educated hundreds of physicists, who then used it to inform their communities and Congress on the issues. This helped erode congressional support for the system until President Richard Nixon was forced to negotiate the U.S.-Soviet Anti-Ballistic Missile Treaty of 1972, which limited each country to two (later one) interceptor sites.[9] The United States shut down its permitted site in 1976 after only a few months of operation.

After President Ronald Reagan announced his Strategic Defense Initiative in 1983, Bethe and collaborators again explained the many Soviet options to defeat the proposed system, which this time was to include a constellation of orbiting lasers.[10] Once again, their technical critique contributed significantly to the erosion of congressional support for what became derisively known as “Star Wars,” and the development program lost most of its funding.

No New Nuclear Weapons
After the end of the Cold War and on the occasion of the 50th anniversary of Hiroshima in 1995, Bethe at the age of 88 decided that it was time to call on the world’s weapons scientists to help end what he had helped begin. He used Los Alamos as a platform to address scientists there directly as well as scientists around the world through the press:

Looking back at the half-century since [their creation], I feel the most intense relief that these weapons have not been used since World War II, mixed with the horror that tens of thousands of such weapons have been built since that time—one hundred times more than any of us at Los Alamos could ever have imagined.

Today we are rightly in an era of disarmament and dismantlement of nuclear weapons. But in some countries nuclear development still continues. Whether and when the various nations of the world can agree to stop this is uncertain. But individual scientists can still influence this process by withholding their skills.

Accordingly, I call on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons—and, for that matter, other weapons of potential mass destruction such as chemical and biological weapons.[11]

ENDNOTES


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