

Hans Bethe: Superlative Scientist, Incomparable Mentor, Humanitarian, Friend

With the death of Hans Bethe, an era has come to an end. He was the last of the young physicists who, from 1925 to the early 1930s, established quantum mechanics. The formulation of quantum mechanics was the result of a collective effort initiated by Werner Heisenberg, Max Born, Pasqual Jordan, Paul Dirac, Erwin Schrödinger, and Wolfgang Pauli. Its wide-ranging applications and extensions were the work of the physicists who came of age as it was being created: Bethe, Felix Bloch, Walter Heitler, Lev Landau, J. Robert Oppenheimer, Rudolf Peierls, Eugene Wigner, and others. In two lengthy *Handbuch der Physik* articles published in 1933, Bethe gave a masterful exposition of the application of quantum mechanics to atomic, molecular, and solid-state physics. Those articles set the standards for the subsequent contributions to these fields, and they have remained classics to this day.

During the 1930s, the frontiers of physics shifted to nuclear physics and cosmic-ray physics, and Bethe became an acknowledged leader in those fields. His mastery of nuclear physics made it possible for him to put forward in 1938 his explanation of energy generation in stars, for which he won the Nobel Prize in Physics in 1967. Beginning in 1928 and continuing for 75 years, Bethe published more than 300 papers on an astonishing array of scientific subjects, from atomic physics to astrophysics, from quantum field theory and elementary particles to shock waves, neutron stars, and supernovae. Many of his papers charted the subsequent developments in those fields.

In 1933, after Hitler came to

power, Bethe lost his assistant professorial position in Tübingen because his mother had been Jewish. In February 1935, he came to Cornell, where he stayed until the end of his life. He became an outstanding teacher and mentored several generations of PhD candidates, postdocs, and research associates.

His experiences during World War II transformed his life. Bethe was the supreme example of why theoretical physicists were so valuable to the war effort. He had the ability to translate his intellectual mastery of the microscopic world of nuclei, electrons, atoms, and molecules into an understanding of the macroscopic properties of materials and the design of macroscopic devices, such as radar generators and antennas, and atomic bombs. That ability rendered his services so valuable at MIT's Radiation Laboratory, and at Los Alamos, where Bethe headed theoretical physics, the division that designed the uranium bomb—which was not tested before its use on Hiroshima—and later the plutonium bomb.

Los Alamos was unique in its enormous concentration of first-rate people who constantly proved what could be accomplished by working together on very circumscribed goals that they believed were in the service of a just cause. Although isolated—and perhaps because of its isolation—Los Alamos created that rare situation in the lives of individuals and communities when they feel in touch with much more than themselves. During the few years they spent there, almost everyone, particularly the physicists, felt whole. Their commitments, aspirations, inspirations, and talents merged into a single purpose.

Not only did the Los Alamos participants feel whole as individuals because their moral, intellectual, and creative passions were channeled into the task at hand, but an atmosphere of wholeness permeated the entire enterprise, transmuting it into a kind of magic and enshrining it in the minds of those who had

been there. In many ways, Bethe personified the integration of the enterprise's many facets: the theoretical and the experimental, the idealistic and the down-to-earth, the individual and the community.

Los Alamos also gave proof of a deep difference between Europe and the US in the meaning of marriage. In contrast to American scientists, all the "refugee" scientists who worked at the lab—Bethe, Peierls, Edward Teller, Victor Weisskopf—told their wives the character of the work they would be engaged in. Bethe not only informed his wife, but discussed with her the morality of working on such weapons, and the decision to do so was a shared one. In 1951 Bethe again conferred with his wife, when he decided to help implement the design of a hydrogen bomb—after initially opposing it—in order to maintain what would later be called the "balance of terror."

When physicists returned to their universities after World War II, they tried to recreate the spirit of cooperation, commitment, and wholeness that had permeated the wartime laboratories, and Los Alamos in particular. The Newman Laboratory of Nuclear Studies at Cornell was Bethe's attempt to do that. Through his own work and that of the physicists he gathered around him, he created not only one of the world's finest centers of high-energy physics but also a research center imbued with a sense of community.

It was part of Bethe's greatness that he was able to endow the Newman Lab and the physics department at Cornell—in fact, all the communities he belonged to—with the qualities and norms that he was deeply committed to. His beliefs were that such communities exist under the constraints of cooperation, trust, and truthfulness; that they be uncoerced in setting their goals and agenda; and that they be committed to the growth of knowledge and civility and be open to new ideas and ways of thinking. Such communities were, for him, the guarantors that a

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most exalted human aspiration—"to be a member of a society that is free but not anarchical," as I. I. Rabi had put it—could indeed be satisfied. And Bethe believed that such communities were models for how larger democratic societies could operate.

All his life, whether working on nuclear weaponry, nuclear energy, nuclear test ban treaties, arms limitation treaties, or whatever assignments and responsibilities Bethe took on as a citizen with outstanding scientific and technological expertise, he believed those works would enable the US to make the planet a better and safer place for all humankind. It was with anguish and trepidation that he observed the paths taken by the present administration when addressing issues related to nuclear weaponry, the environment, test ban treaties, and scientific advice.

Few people have given so much to their discipline, their communities, and their country. Few people have done so as selflessly, sensitively, and wisely. We have all been diminished by his death.

Silvan S. Schweber
(schweber@mit.edu)

Dibner Institute

*Massachusetts Institute of Technology
Cambridge*

Ideas Generated for Transforming the Electric Infrastructure

Clark Gellings and Kurt Yeager, in their article "Transforming the Electric Infrastructure" (PHYSICS TODAY, December 2004, page 45), propose "distributed energy resources" as part of the solution to transforming and modernizing the electric power infrastructure. They recommend "small generation and storage devices distributed throughout" the system, but suggest only "fuel cells and batteries" and offer no details of how the cells and batteries could be created economically or how they would be integrated. Much more appropriate devices already exist and are currently proliferating—namely, hybrid gasoline–electric vehicles, such as the Toyota Prius.

Although nominally designed as transportation, hybrid vehicles normally perform that function for only an hour or so per day. The rest of the time they are small standby generator plants. With their capacious batteries, they could supply tens of kilo-

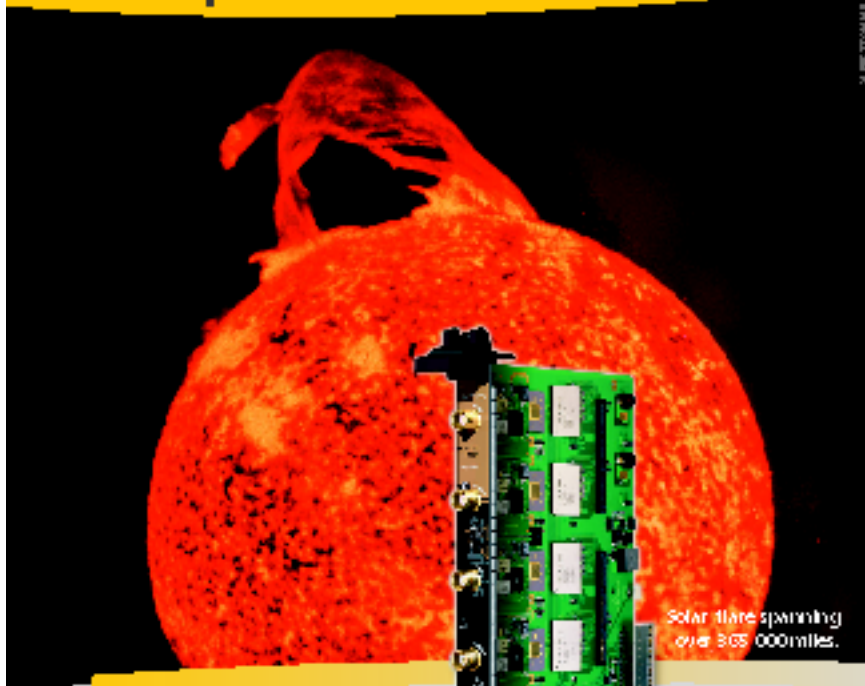
watts of instantaneous power to cover peak demands for electricity. The continuous power output of hybrids is several kilowatts, commensurate with the power required not just to drive down the highway but also to run a house.

On the power-receiving end, vehicle "docking stations" with DC-to-AC inverters and transfer circuits could turn a house, a factory, or even a community into a self-sufficient entity. Although such facilities aren't free, their cost is much less than

that of the typical power station and, if mass produced, might come in under \$1000 plus professional installation. Given the many power emergencies and inconveniences during this past hurricane season, I can see at least one section of the country jumping at the opportunity.

Consider what could be accomplished as the hybrid fleet size increases and its power is harnessed:
► Individual homeowners could sign up for voluntary disconnection from the grid. With continuous internet

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