Professor Hans A Bethe – A Brief Homage

When Professor Hans Bethe passed away on March 6th 2005, he was arguably the most revered physicist in the world. This was not so much because he had physically outlasted fellow giants of his time. That was already a big achievement – to have lived an amazingly productive life up to the age of 98 and confounded scientists half his age by continuing to do state of the art research well into his nineties.

But he had attained the status of being the doyen of the physics community long before that, through the all-pervasive breadth of his research, his contributions to public policy in science, and the statesmanlike role on both these fronts that naturally fell upon his shoulders.

Hans Albrecht Bethe was born on July 2 1906 in Strasbourg, Alsace-Lorraine, Germany into a very emancipated middle class family. His father was a physiology professor and his mother a talented pianist. Young Hans went to the Goethe Gymnasium in Frankfurt where he was a model student who distinguished himself in both mathematics and physics, although, it is said, not in gymnastics! But in later life he became an untiring hiker of mountain trails.

He got his PhD in theoretical physics in July 1928. His supervisor was the master theoretical physicist of the time, Arnold Sommerfeld. After his PhD Bethe spent a few postdoctoral years at different places in Europe (one of which was spent working with Enrico Fermi at Rome). By that time a major social upheaval was building up in and around Germany due to the increasing persecution of Jews by the Nazis. Because he was part-Jewish (his mother had been born Jewish), Bethe lost his job and had to leave Europe. After a year in England, he eventually found his ultimate home in the small but gorgeously beautiful town of Ithaca in the United States where, in 1934 he was appointed a Lecturer at Cornell University. Within 3 years he was promoted to a full Professorship. Cornell was good to him and he in turn stayed loyal to Cornell and Ithaca until the end of his life, despite numerous attempts by other institutions to entice him away.

In theoretical physics Bethe had done seminal work decade after decade, in one area of physics after another. He belonged to the generation that succeeded the pioneers of Relativity and Quantum Theory (Einstein, Bohr, Heisenberg, Schrodinger, Dirac,

Max Born …). These theories formed the deep conceptual foundations of modern physics. But it still remained to construct, based on the principles of quantum mechanics and relativity, individual theories of widely different domains of physics. As the worlds of atomic, nuclear, condensed-matter, and sub-nuclear physics were unveiled through the ingenuity of experimental physicists, Bethe played a major role in the theoretical understanding of each of these worlds.

His role was particularly dominant in nuclear physics. He was sometimes referred to as the father of nuclear theory because of the set of comprehensive review articles he wrote on nuclear theory in the 1930's, often called 'Bethe's Bible', which essentially acted as the first textbook in the newly born field of nuclear physics. He worked on various aspects of nuclear theory – nuclear forces, nuclear reactions and scattering, bound states like the deuteron and finally the fundamental theory of nuclear matter.

He also extended his interest in nuclear reactions to investigate those that produce the energy radiated by stars like our own Sun. After an exhaustive theoretical analysis of various reactions he identified a particular sequence, where carbon acts as a catalyst to enable four hydrogen nuclei (protons) fuse into a helium nucleus, as the major source of energy production in most stars. It was for this work, among his several Nobel-worthy contributions, that Bethe was awarded the Nobel Prize in 1967. This body of work, along with that of Gamow, also launched the field of nuclear astro-physics.

Bethe's research was characterized by a relentless focus on calculating, using simple analytical tools, accurate concrete results without getting lost in excessive formal theory or extensive numerical calculations. An example which illustrates this well is his calculation of the famous Lamb shift in quantum electrodynamics. He is believed to have made this entire calculation on his writing pad, even as he was traveling home by train from the conference where he had heard of the problem! In addition to his work on nuclear, particle and astro-physics, Bethe had also made pioneering contributions to solid state physics, fluid dynamics, shock waves, radar theory and reactor physics. In fact his earliest major work, based on his doctoral studies with Sommerfeld, was actually in solid state physics, resulting in a seminal survey of the electronic theory of metals published in 1933 in the *Handbuch der Physik*.

Bethe also had a major role to play in the creation of nuclear weapons as the Head of Theoretical Physics in the Manhattan Project for developing the first the atomic

bomb. As the horrible effects of the bomb were revealed by the holocausts in Hiroshima and Nagasaki and as nations went on to build huge arsenals of more and more powerful nuclear weapons, Bethe, like all scientists who had participated in the original development of the bomb, went through much soul-searching. But Bethe remained convinced that his reasons for working on the bomb, in the context of the war with Nazi Germany which was believed to be working on its own atom bomb, were valid.

He however opposed further development of bigger weapons after the War, including, at its initial stages, the fusion (Hydrogen) bomb. As a leading scientific advisor to successive Presidents of the United States, he argued vehemently for disarmament and worked on various technical aspects of test ban treaties and the anti-ballistic missile treaty. In later decades he was one of leading scientists who opposed Reagan's Star Wars Project. It is a tribute to Bethe's statesmanlike qualities, his calm and measured way of reaching his decisions and conveying them and his willingness to listen to others, that despite having been associated with building the first bomb, he was admired by and respected by doves and hawks alike.

I had the privilege of working closely with him for many years, first as his PhD student and later as a faculty colleague at Cornell and co-author. He was always kind to me and showed great patience with my pretentious fancies about physics and its practice. It is an honour to contribute to this issue of *Resonance* dedicated to his memory.

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Prof. Bethe, on the far right, at the author's wedding at Cornell in 1968.