Obituary

Frederick Reines (1918–98)

Discoverer of the neutrino

For three months in 1951 a young Fred Reines sat in an empty office at Los Alamos, staring at a blank pad of paper on his desk. Following his final work on the effects of nuclear blasts at Eniwetok Atoll, he had requested a leave-in-residence to contemplate what he might do with his life. His years on the Manhattan Project under Hans Bethe and Richard Feynman placed him in the company of many of the greatest minds in science. The experience inspired him to seek some new way to address the central problems of physics.

His pondering spawned a bold idea. He would try to detect the free neutrino. Some 20 years before, Wolfgang Pauli had postulated the neutrino as a way of dealing with a disturbing violation of energy and momentum conservation observed in radioactive decay. Although he was not comfortable with his solution, Pauli proposed to save the conservation laws by assigning the missing energy and momentum to a ghostly new particle. As Pauli put it, “I have to replace something we do not understand with something else we cannot observe”. Indeed, Bethe and Rudolf Peierls wrote in *Nature* in 1934, “...there is no practically possible way of observing the neutrino”.

Yet, because the particle had later been embraced in a highly successful theory of β-decay by Enrico Fermi, at the time of Reines’s deliberations nearly everyone believed that the neutrino was a reality. Why would Reines want to risk his career on a dubious attempt to prove what was already accepted? He claimed to be motivated simply by a stubborn desire to do the impossible. But his friends know better. Reines had an instinct — a feeling that there was something absolutely fundamental about the neutrino. In defiance of contemporary fashion, he set upon his heroically difficult quest.

Trained as a theorist, Reines had received his PhD from New York University in 1944. He would now have to become an experimentalist. He joined forces with Clyde Cowan, and together they contemplated a particle with no electric charge and little if any mass, that interacted so weakly with matter that the entire Earth is highly transparent to it. A fission bomb seemed the only adequate neutrino source; but fortunately they realized that, in a large liquid scintillation detector, the signature of an antineutrino captured on a proton would be so distinctive that the experiment could be performed under more controlled conditions near a nuclear reactor.

The experiment was mounted at the Hanford plant in Washington state, where a hint of a signal was seen. Encouraged, they moved to a more favourable environment at a Savannah River reactor in South Carolina, and installed an improved detector. Following an exhaustive series of tests, the interaction of free antineutrinos on protons was firmly established in 1956. Reines and Cowan announced their victory in a telegram to Pauli at CERN, the European physics facility.

An entire new field of physics and astronomy had been opened up. Now that we could capture neutrinos from reactors, why not neutrinos from the Sun, from cosmic rays and from collapsing stars? Rightly known as the father of neutrino physics, it is Reines, perhaps more than any other scientist, who is identified with the discovery of a fundamental particle and its subsequent development as a tool for revealing new knowledge. He went on to exploit the huge antineutrino flux at Savannah River to establish basic properties of the neutrino and search for exotic new physics.

In 1959 he accepted a position as chair of physics at Case Institute of Technology, where he continued his pursuit of neutrino physics on many fronts. He built enormous scintillation and water Cerenkov detectors in deep mines to escape cosmic-ray background and to search for solar and extra-solar neutrinos, as well as neutrinos from the interaction of cosmic-ray primaries in the Earth’s atmosphere. Another thread in his extraordinary career was his testing of conservation laws. No law was too sacred to escape his experimental scrutiny. He extended the limits on conservation of electric charge and of baryon number. He searched for lepton-number violation and evidence of neutrino–antineutrino identity in an experiment on neutrino-less double-β-decay, and he nurtured double-β-decay experiments done by others.

Among his ‘firsts’ were the detection of atmospheric neutrinos, of elastic scattering of antineutrinos on electrons, and of weak neutral current interactions of electron antineutrinos on deuterons; and the remarkable identification of a burst of neutrinos, from supernova 1987A, that confirmed the place of the neutrino in theories of stellar collapse.

Reines’s philosophy of experimental physics is perhaps best illustrated by remarks he made while at the University of California at Irvine, where he had worked since his arrival as founding dean of physical sciences in 1966. During the 20 years that the elastic scattering experiment was under way, guidance from theoretical developments was constantly changing. Had he been influenced by these developments it would have distracted him from the steadfastness that led to the eventual detection. In his own words, “This is not to say that experimentalists should proceed independently of theory, but it does suggest that the coupling should not be too tight”.

A large man with a determined expression and a deep, booming voice, Reines was an imposing figure to his young graduate students. There was an intensity about him that told of a course well set, with no impending obstacle able to withstand his will. Yet beneath was a kind and playful spirit who whistled in the stair wells, sang songs from Gilbert and Sullivan, and who used his deep voice to great effect in telling jokes he had heard in Russia. While at Case, Fred contributed his fine baritone to the chorus of the Cleveland Symphony Orchestra.

For his discovery and pioneering investigation of the neutrino, Fred Reines shared the 1995 Nobel prize in physics with Martin Perl, discoverer of the tau lepton. Retired in 1988, he remained at Irvine as distinguished emeritus professor of physics until his death on 26 August. He will be missed by his many friends the world over.

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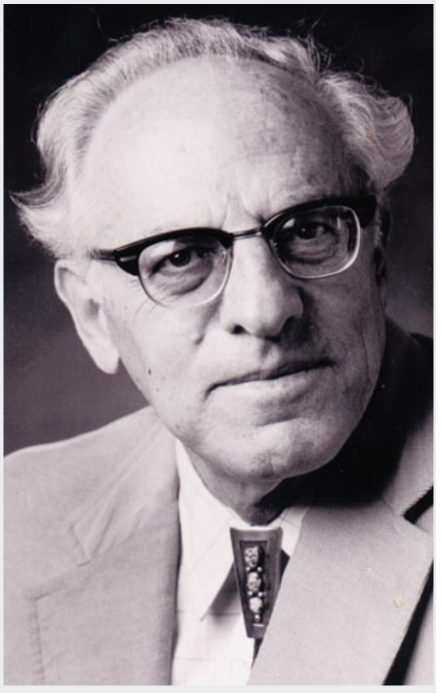

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