NUCLEAR PHYSICS

Toward Nuclear Truth

Ten years after a universal theory of weak nuclear interactions was proposed, the predictions based on it continue to show better and better agreement with experiment. The experimental tests giving excellent support to the so-called "V-A Theory of Weak Interactions" have been conducted since 1957 with several atom smashers by many nuclear particle physicists at many laboratories, not only in the United States but around the world.

It was not until about 35 years ago that physicists clearly recognized the existence of two or more forces within the atomic nucleus—the strong, or nuclear, interaction and the weak interaction.

Scientists had previously recognized Isaac Newton's universal law of gravitation, which explains in one theory why a stone falls to earth, a satellite circles the earth and the motion of the planets around the sun.

In the early Nineteenth Century, Maxwell's equations accomplished the same feat for electromagnetism, expressing concisely the universal laws governing electromagnetic interaction among charged particles and electric currents.

The four known forces rank, in order of descending strength: strong nuclear, electromagnetic, weak and gravitational. The number of possibilities for strong and weak nuclear forces multiplied rapidly as new particles were discovered.

In order to achieve some unified understanding of particle interactions, scientists have searched for a universal theory of both strong and weak interactions.

The physicists' ultimate goal is a unified theory of elementary particles in which the common origin of all the forces—gravitational, electromagnetic, strong and weak—will be understood. Although that objective has not been attained, scientists are glad to have a universal law that will describe each separately. The one that best explains strong nuclear interactions is known as "SU-3 symmetry."

The one that has proved successful for weak interactions is the V-A Theory, physicists' shorthand for Vector-Axial Vector Theory. It was first proposed in the summer of 1957 by Dr. Robert E. Marshak, of the University of Rochester and E. C. G. Sudarshan, then a student there. Several months thereafter, Drs. Richard P. Feynman and Murray Gell-Mann of California Institute of Technology had independently proposed a theory of weak nuclear interactions that included the V-A hypothesis.

Although there are many particle interactions by which the weak theory can be tested, only five of them have so far proved amenable to experiments. A table of the results predicted theoretically and those found experimentally are in extremely close agreement, putting the V-A Theory of Weak Interactions on a very firm basis.

Nuclear interactions in which there is close agreement between theory and experiment listed by Dr. Marshak are the decay of a positive pi meson, two decay modes of positive K mesons, the disintegration of a lambda meson and the decay of a negative sigma meson.

Theory	Experiment
1.23×10^{-4}	$(1.24 \pm 0.03) \times 10^{-4}$
2.47×10^{-5}	$(3 \pm 1.89) \times 10^{-5}$
0.69	0.703 ± 0.056
5.88	5.87 ± 4.75
0.45	0.496 ± 0.26

Dr. Robert E. Marshak

Universality proved experimentally

Dr. Marshak believes that the last ten years have shown "tremendous progress in achieving the objective of a universal law of weak interactions among the elementary particles."

The V-A Theory, he notes, has "survived almost intact except for one important modification," based on the SU-3 theory that is now the best available explanation for certain strong nuclear interactions.

The many calculations made during the last two years because this modification was suggested "have all tended to confirm the essential correctness of the universal V-A Theory," Dr. Marshak says.

He believes that the basic reason making the modification necessary will be understood only within the framework of a comprehensive theory covering all nuclear interactions, one that explains both the strong as well as the weak forces.