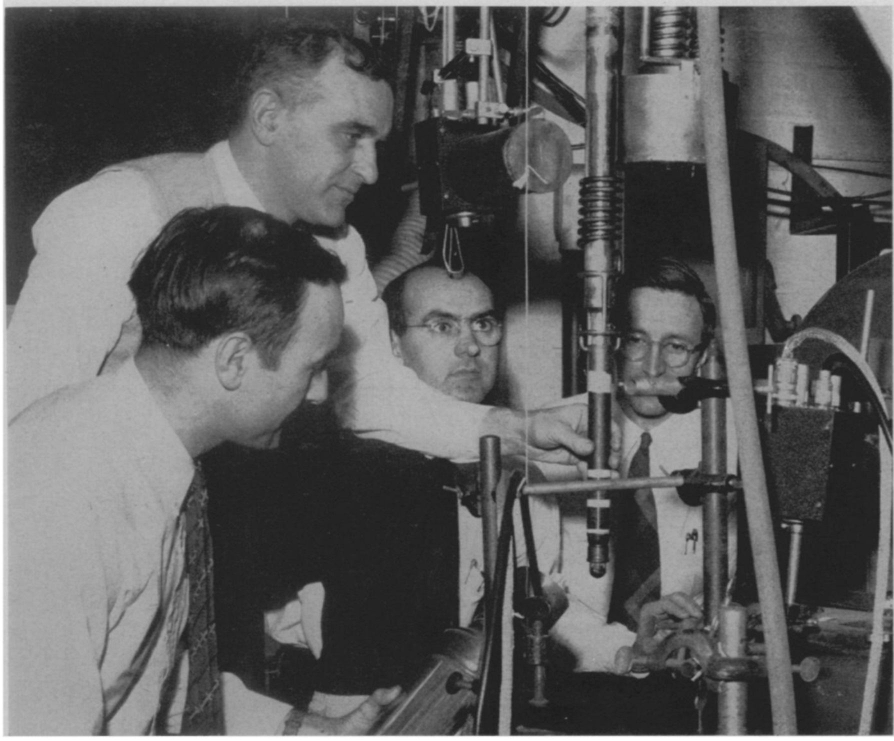
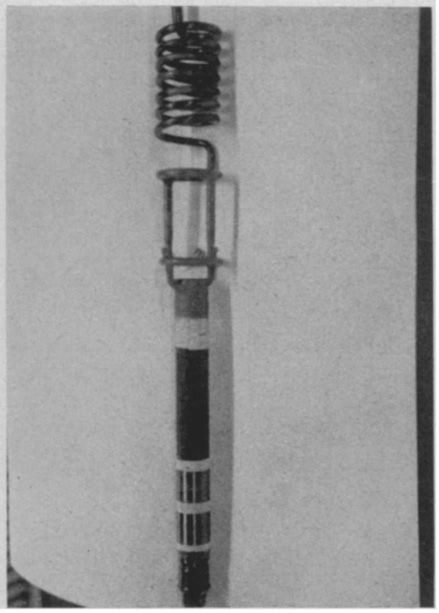
BEHIND THE NEW LAWS — Left to right top row are Dr. T. D. Lee, Columbia University; Dr. C. N. Yang, Institute for Advanced Study; and associate professor Chien Shiung Wu, Columbia University. Second row shows Dr. R. L. Garwin and Prof. L. M. Lederman of Columbia University. Lower left shows the group of scientists from the National Bureau of Standards assembling low temperature equipment used in their experiments which helped to disprove the principle of "conservation of parity." Left to right they are Dr. Ralph P. Hudson, Dr. Ernest Ambler, Mr. D. D. Hoppes and Dr. R. W. Hayward. Lower right shows the heart of the apparatus used by the National Bureau of Standards and Columbia University scientists in aligning radioactive cobalt 60 nuclei and measuring the directional intensity of beta radiation from the nuclei. The Bureau of Standards' experiments were conducted in the Bureau's cryogenic physics laboratory in cooperation with Columbia University.





NUCLEAR PHYSICS

New Atomic Matter Laws

A revolution in theoretical physics has been created by new knowledge of the disintegration of meson particles. Principles accepted for three decades are disproved.

➤ THE LAWS of matter governing the action of elementary particles that make up all of the universe have proved different from those scientists for three or more decades have assumed.

The whole body of theoretical physics as it relates to building blocks within the atom's core has been "cracked wide open" in the same way that Einstein with his theory of relativity remade the physical world about the time of World War I.

Two sets of experiments reported from the department of physics at Columbia University have created this revolution. These experiments relate to the way in which the little known meson particles disintegrate.

In one case, a Chinese woman physicist, associate professor Chien Shiung Wu, born in Shanghai, together with Drs. E. Ambler, R. Hayward, D. D. Hoppes and R. P. Hudson, a group of National Bureau of Standards scientists, studied the beta decay of oriented nuclei. In another case, a group from Columbia University, Dr. Richard L. Garwin, Prof. Leon M. Lederman and Marcel Weinrich, studied the angular asymmetry in electron decay of mu mesons.

Both of these experiments were suggested by two theoretical physicists, both Chinese born, Dr. T. D. Lee of Columbia and Dr. C. N. Yang of the Institute for Advanced Study, Princeton.

Parity Questioned

They wanted an answer to whether what physicists call parity is conserved, as it has to be under the older formulations now destroyed. In effect, both experiments, conducted in one case at sub-frigid temperatures at the National Bureau of Standards and in the other case with Columbia's Nevis cyclotron, demonstrated that the conservation of parity or the "invariance of spatial inversion" is not correct.

This can be explained by imagining that, if spinning particles existed in this world and were compared with particles in another world, it would be possible by the sense of rotation to determine whether they are right-handed or left-handed in their spin. This would not be possible under the older parity idea.

The old theories which have worked in connection with modern physics, just as classical mechanics worked in practical things before Einstein's relativity, are known to be inaccurate by one part in ten to the 25th power, or one part in 10 followed by 25 zeroes.

An effect of this size could not be discovered in strong interactions between particles and only showed up in the very weak effect of the unusual particles used.

The concept of parity, although actually significant only in the realm of microscopic atomic and particle physics, has a well defined every-day definition. One way of describing this is as follows:

Suppose we are in communication with an intelligent civilization on another world and wish to determine whether they mean the same thing by left-handed and right-handed as we do.

We have always believed that communication of this idea, in the spirit of this analogy, is impossible. There was no absolute, universal sense to "handedness." However, the stranger's laws of physics are perfectly good—even if his definition is opposite to ours for, say a left hand screw and right hand screw.

Invariance Principle

The statement that the two worlds, one based upon a left-handed system and one based upon a right-handed system, have the same laws in physics is known as an "invariance principle."

The interchange is a reflection in the sense that a mirror image is a reflection in the plane of a mirror. Physicists refer to this reflection as a "parity operation." The principle of invariance to parity operation has been built into physical theories since 1925 and serves as a severe restriction on the types of laws predicted by these theories. It is this principle that was destroyed by the recent Columbia experiments.

Scientists there discovered that neutrinos and mesons possess "handedness' as an intrinsic property. These particles must now be considered to possess, in addition to charge, mass, spin, etc., properties analogous to a screw, that is, a favored rotation or spin and an advance along the axis of rotation, either right-handed or left-handed.

The elementary spinning particle can be compared to a spinning bullet. If the bullet were a perfect cyclinder, there would be no handedness, since the two ends of the bullet would be identical. The new concept of particles is now in analogy with a normal bullet, thus differentiating one end of the spin from the other. Particles which "point" in one direction relative to the sense of rotation are called right-handed, etc.

That such particles exist on this world and on the other theoretical world permits an absolute identification of right and left hand between the two worlds, in violent disagreement with previous concepts. No theory including the parity idea could have been successful.

The experiments, brilliantly proposed by Drs. Lee and Yang, open the way to a correct and unifying theory of elementary particles.

The proposal that the parity law may not be true was made in an attempt to reconcile data concerning one aspect of K-meson disintegration that seemed to violate the parity law. So deeply rooted was this law, that physicists were completely baffled by the K-meson puzzle. Drs. Lee and Yang boldly, in their historic paper, re-examined the consequences of removing the parity law for radioactive disintegrations of nuclei and particles.

Experiment With Cobalt 60

They found that none of the existing data would be in contradiction and that certain crucial experiments could give decisive answers.

Cobalt 60 was cooled to a temperature of 0.01 degrees above absolute zero where all thermal motions are reduced to extremely small values.

Applying a magnetic field will make most of the spinning cobalt nuclei align themselves, like small magnets, parallel to the applied magnetic field. The radioactive cobalt nuclei disintegrate, giving off electrons.

The number of electrons emitted along the direction of spin can then be compared to the number going in the opposite direction. These numbers are different, indicating the favoring of a direction associated with the spin, that is, a "handedness" in the sense of a screw.

The difference was sufficiently large to indicate a violation of "charge conjugation invariance."

In another experiment, two parity violations were detected, as well as the violation of "charge conjugation invariance."

It was discovered that, when the familiar pi meson . . . believed principally responsible for the force that holds nuclei together . . . disintegrates into a mu meson and a neutrino, the mu meson always spins in the direction of its motion.

The mu meson advances as if it were a screw and demonstrates the parity-violating "handedness." The alignment of mu spins was detected by counting the end products of the radioactive mu meson decay, electrons, which were found to favor one direction of spin of the parent mu meson over the other, in their direction of emission.

As a by-product of this experiment, the strength of the small "magnet" carried by the mu meson, the magnetic moment, was measured to a precision of five percent. Magnetic moments of electrons are known to precisions of 0.005 percent.

The experiments are continuing in the expectation that they will throw some light upon the matter of the reversal of time, that is, if events were run backward like a movie projector, could the difference be told. The scientists emphasized that now the door is open to a new foundation for elementary particle physics.

Science News Letter, January 26, 1957