NUCLEAR PHYSICS

SynchrotronMakesMesons

This powerful new atom-smasher has produced cosmic ray particles by radiation. First direct evidence that this can be done.

See Front Cover

➤ CREATION of the mysterious cosmic ray particles called mesons from the world's most powerful X-ray beam was reported to the American Physical Society in California by Dr. Edwin McMillan of the University of California Radiation Laboratory.

Dr. McMillan said that the cosmic ray particles had been made in the laboratory with the 300,000,000 electron-volt synchrotron.

Production of mesons by radiation in the synchrotron is believed to be the first direct evidence that these potent particles can be made from electro-magnetic radiation. Light, heat, electricity and radio waves are forms of electro-magnetic radiation. Another is the X-ray beam of the synchrotron.

The synchrotron, invented by Dr. McMillan, uses electrons, negatively charged electric particles, to bombard a heavy metal target. This creates the powerful, highly-penetrating X-ray beam.

The atom-smasher is three times as powerful as its cousin, the betatron, another type of electron accelerator; and several times as powerful as three smaller operating synchrotrons, two in England and one in the United States, which have a capacity of 70,000,000 electron volts or less.

Finer Atom-Smashing Tool

The synchrotron is a finer atom-smashing tool than the giant cyclotrons. The fine radiations it produces are expected to duplicate many of the phenomena observed in bombardments with the heavy nuclear projectiles—protons, deuterons and alpha particles—of the cyclotrons.

In addition, the synchrotron may produce cosmic ray showers similar to those found in nature, and may be the means for determining if neutrons and protons are divisible.

Vibrations caused as 160 kilowatts is thrown into and drawn out of the 135-ton electro-magnet cause parts of the machine literally to shake. The concrete foundation vibrates, in spite of the rubber pads on which the machine is mounted, and the synchrotron almost appears to be dancing a jig.

A loud noise accompanies operation. As the machine is turned on, a low thumping is heard, and this builds up to a loud, regularly spaced hammering as the magnet reaches full power, a noise akin to a high-powered diesel engine. Observers have remarked that this is an atom-smasher in which the atoms can be heard to crack.

The synchrotron is based upon the concept of phase stability which during the postwar period has revolutionized atom-smashing and upon which are based the billion-volt machines now on the drawing boards.

This concept is the theory of phase stability, originated independently by Dr. McMillan and the Russian scientist, Veksler, in 1945. This theory circumvents the Einstein relativity principle which had apparently put a ceiling on the energies to which particles could be accelerated.

Theory of Relativity

Relativity states that as a particle gains energy it gains mass; and while the particle, when it becomes heavier, can still be accelerated, this can be done only at a slower rate. In prewar atom-smashers this meant that as projectiles reached higher energy they would lag and fall out of step with regularly timed pushes of prewar atom-smashers.

The synchrotron gets around this in a unique way. As the electrons reach higher and higher energy, the power of the field of the magnet is increased proportionately. The result is that the laggard electrons are jerked up to the acceleration point in time to be propelled to higher energy.

Electrons are accelerated in a doughnut-shaped quartz chamber, two meters in diameter, which is placed between the ring-shaped poles of the electro-magnet. The quartz chamber is silver plated, except for a short section, a gap at which point the particles are propelled.

When electrons are injected into the chamber, they are first hustled around the orbit by the sheer force of the magnet acting on the particles. Up to 2,000,000 electron volts, the machine thus operates as a betatron.

At 2,000,000 electron volts, high frequency power is poured on the silver plating of the chamber, making it a resonant cavity. Operation is timed so that as the electrons reach the gap in the cavity, the far side of the gap is positively charged. This attracts the electrons violently across the gap, speeding them up. By the time the electrons go around the circle again, the current has gone through a complete cycle, and the electrons receive another push. The oscillator providing the accelerating current is capable of reversing the alternating power 48,000,000 times a second.

The magnet guides the particles around the orbit.

The synchrotron goes through a full operation six times each second. For each operation, lasting for a period of one-thirtieth of a second, a "flight" of electrons is accelerated to full energy. Each "flight" tours the chamber 480,000 times before it reaches 300,000,000 electron volts. By the time an electron reaches that energy, it weighs 600 times what it did at rest.

When a flight of electrons reaches peak energy, the oscillator is turned off. The electrons, no longer receiving accelerating impulses, spiral inward, strike a heavy metal target, and liberate X-rays.

Power Stored in Condenser

Power for the synchrotron magnet is stored in the largest condenser bank in the world, which acts like a storage tank as shown on the cover of this week's SCIENCE NEWS LETTER. The "tank," consisting of 3,328 condensers and storing 100,000 joules, is kept full by an ordinary power line.

During the one-thirtieth second operations, this tremendous power is switched into the magnet and back into storage again by four ignitrons. The power loss is small, and this makes for economy.

The magnet has a field strength of 10,000 gauss, stands 98 inches high, 194 inches long, and 92 inches in breadth.

Dr. McMillan's chief associate in construction of the machine was Marvin Martin, engineer in the Radiation Laboratory.

TINY TUBES FORM CLAY—This tubular structure of a common red clay called halloysite was discovered by studies with an electron microscope, which magnified the clay up to 60,000 times. This picture of halloysite and other clays was made at Pennsylvania State College by Thomas F. Bates, Fred A. Hildebrand and Ada Swineford.

They were assisted primarily by Drs. Robert Serber, Wilson Powell, A. C. Helmholz and by George Farley and Leslie Cook, all of the Radiation Laboratory scientific staff. Walter Gibbins was in charge of the work crew.

Science News Letter, February 12, 1949

NUCLEAR PHYSICS

Beam of Atomic Bullets

➤ THE world's most powerful beam of protons, a special kind of atomic bullet, has been fired by the giant cyclotron at the University of California. The protons pack 350,000,000 electron volts of energy.

This was reported to the meeting of the American Physical Society in Berkeley, Calif., by Dr. Kenneth MacKenzie, who collaborated with William Brobeck, assistant director of the Radiation Laboratory, in designing new equipment for the machine.

The 4,000-ton cyclotron has been the world's most powerful since it went into operation in 1946. But heretofore it accelerated only deuterons, the nuclei of heavy hydrogen atoms, and alpha particles, the nuclei of helium atoms. Protons are the nuclei of ordinary hydrogen.

New equipment installed in the machine in December makes it possible now for Berkeley scientists to switch at will from one to another of the three types of atomic bullets. Operation of the machine is a part of the University's research program for the Atomic Energy Commission.

In a second scientific paper, Dr. Robert Thornton, physicist in charge of the big machine, said that neutrons produced in bombardments by the protons range in energy up to 350,000,000 electron volts. The previous top energy for neutrons was the 100,000,000-electron-volt-beam produced by deuteron bombardments with the same cyclotron.

When the protons strike target atoms, the smash-up produces mesons, the penetrating cosmic ray particles first made in the laboratory at Berkeley in alpha particle bombardments.

Research with the protons will enable scientists to penetrate farther into the atomic nucleus and to learn more about its structure.

Acceleration of protons was made possible by changes in the oscillator, which supplies the radio frequency power to drive the atomic bullets around the cyclotron chamber. The change was necessary partially because the proton, only one half the weight of the deuteron, travels faster.

With protons, the oscillator starts out by giving the particles a push 50,000,000 times a second. By the time the bullets reach their top energy they have become somewhat heavier and begin to lag; to compensate for the lagging, the pushes at this point come 30,000,000 times a second.

For deuterons, the accelerations at the beginning are 25,000,000 per second and 17,000,000 a second when they reach their top energy.

At 350,000,000 electron volts, the protons have a velocity of 125,000 miles per second (two-thirds the velocity of light). About 1,000,000,000,000 emerge from the atom-smasher each second.

The new oscillator is capable of putting out 100 kilowatts of high frequency power, comparable to a high-powered radio station.

Dr. Thornton said the 10-foot wall of concrete surrounding the cyclotron is sufficient protection for personnel against the high energy radiations.

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INVENTION

Weight On Casting Line Is Made Expendable

➤ BAIT-CASTING fishermen know that a weight is an advantage in getting a good, long cast; but then there's the nuisance of dragging the thing back through the water. Henry L. Oliver of Durango, Colo., and Mina B. Anderson of Albuquerque, N. Mex., provide an expendable weight that tears loose at the end of the cast. On this they have received patent 2,460,526.

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