PHYSICS

Inside The Atom

Although man has tapped the atom to make star-like explosions on earth and to power his machines, he still does not know what is the glue that cements atomic hearts.

By ANN EWING

➤ MAN HAS exploded atomic and hydrogen bombs, powerful nuclear reactions on earth. Although the tremendous energies inside the atom have been trapped, what binds together the contents of atomic hearts is a mystery still to be cracked.

Twenty-one particles in the nucleus are now generally recognized by physicists. Most of them exist only for fleeting bits of seconds. Some of them have strange names such as K pi-two or lambda zero. Others have long been known:

Neutrons, trigger for atomic bombs and nuclear chain reactions;

Protons, positively charged hearts of common hydrogen, and

Electrons, light-weight particles with a negative charge, whose mass movement in conductors produces electric currents.

Combined in various ways, these three basic particles once gave a very satisfactory picture of the 92 kinds of atoms then known.

Unknown Forces

Over 50 years ago, the late Prof. Albert Einstein suggested the equivalence of mass and energy. Over 15 years ago, scientists began to suspect that the energy in the mass of an atomic nucleus could be tapped. But the glue that holds the strange particles inside the nucleus is still not known, even though the blinding flash of nuclear explosions have many times spelled out the equivalence of mass and energy.

Most of the mass of the atom is in its nucleus. Each atom of an element consists of a mist of one or more electrons swirling around the nucleus, millions upon millions of times every second. Although an atom is mostly empty space, the whirling electrons form an impervious shield, keeping everything out of the space within as effectively as though they were everywhere at once.

This smoke of electrons determines the element's chemical properties, from hydrogen with one electron to mendelevium, No. 101, with 101 electrons outside its core. Atoms are so minute that about 200 million of them could be placed next to each other within an inch.

One atom, magnified three billion times, would give a globe about two feet in diameter. Yet the nucleus is so much smaller than the atom itself that, magnified the same amount, it would be barely visible.

Only particles smaller than atoms can get inside an atom. They must have great speed to penetrate the screen thrown up by the electrons and, even then, they often go right through without hitting anything.

When these fragments of atoms do collide with the nucleus, however, sometimes they ricochet, sometimes other particles are thrown out of the nucleus. The resulting scattering, its pattern and the energies of the emerging particles, give clues to the structure of the nucleus.

But they also give one of the biggest headaches—the time lag. Such events unaccountably take about ten billion times longer than would be expected. Scientists have discovered this even though these reaction times range from a millionth to a billionth of a second or less. But why they take so long to react is not known.

Explaining not only the timing but the multitude of particles that come whizzing out of the nucleus under different circumstances are two of the puzzles physicists are trying to solve today. So far each step forward in probing the nucleus has led to more questions than it answers.

And if and when scientists do understand what holds an atom together, the information may or may not be "useful."

Until 1932 a nucleus was thought to be the indivisible atomic heart, made of protons, neutrons and electrons bound together in some unexplained manner.

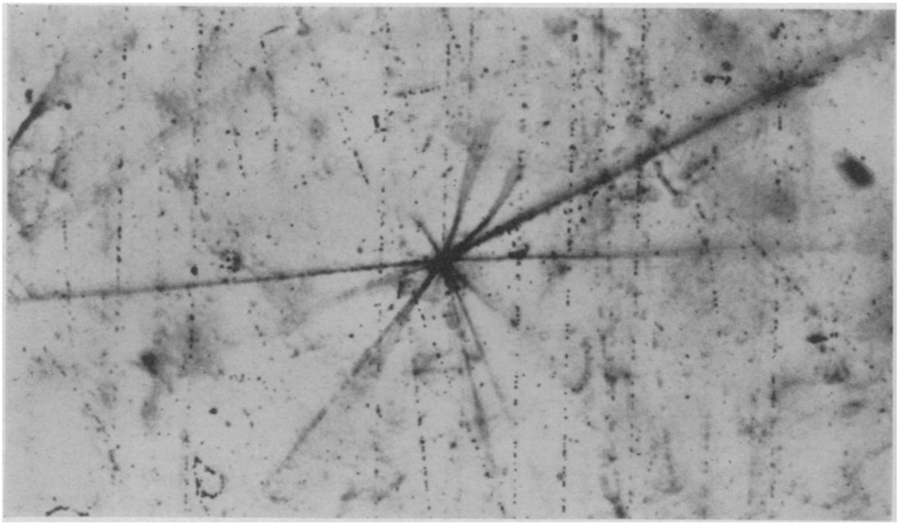
Now physicists wonder whether an "onion" or a "water drop" is a more accurate picture of an atomic heart. For when the core has only a small number of particles, as in oxygen, it reacts to bombarding particles, as if it consisted of easily peeled layers. But when the nucleus has many particles crowded together, as in radium, the picture is more like that of a vibrating water drop which, after swallowing several bombarding particles, suddenly splits into two.

Or, as one scientist explained, the nucleus seems to have a schizoid personality. At low energies, its inhabitants all seem to follow one set of rules, but at high energies, they behave very differently.

Physicists have found a bewildering number of particles can be driven out of the nucleus by other particles, slow ones or fast ones, even by the energy of light itself. From this crowd, some familiar faces are emerging. The particles seem to fall into certain groups having somewhat similar properties.

Of these, the first to be discovered were the light-weight mesons. Mesons are unstable particles, lasting only a few millionths of a second, with a mass between that of the electron and proton. Five examples of this type are now known: three pi mesons, seen with positive, negative and neutral charge, and two mu mesons, one positively and one negatively charged.

A group of heavier mesons, also with masses between that of electrons and protons, are known as K mesons. These include theta zero, K mu-two and Ke, two



STRANGE NUCLEAR REACTIONS—A photographic emulsion exposed to billion-volt protons from the cosmotron at Brookhaven National Laboratory, Upton, N. Y., shows the strange nuclear reactions from which physicists are learning about the nucleus. A high-energy proton, disintegrating an atom in the emulsion from which at least ten particles flew out, caused the "star."

tau particles, one with a positive and one with a negative charge, and K pi-two, either positively or negatively charged.

The third set consists of those with higher masses than protons. Called hyperons, they are lambda zero, negative xi, and two sigma's, positively and negatively charged.

Completing the list of 21 accepted particles besides the electron, proton and neutron are the positron, a positively charged electron, and the neutrino, a tiny particle having little or no mass and no electric charge. The neutrino has never been seen, but its existence, nevertheless, is believed real. A neutrino might well penetrate the entire mass of the sun without reacting.

To analyze atomic hearts and learn about the strange particles that come zooming out of them, scientists use many tools to measure lifetimes, energies and masses.

One of the most promising recently developed devices is called a bubble chamber. Subatomic particles plunging through a superheated solution, kept under high pressure to delay its boiling, produce a train of bubbles. In this manner the bubble chamber is similar in operation to the cloud chamber, which physicists have been using for many years to track the otherwise invisible particles. A cloud chamber is filled with supersaturated water vapor in which the particles cause fog trails to form.

Great advantage of the bubble chamber is that about 20 times as many particles can be caught in it as in a conventional cloud chamber of the same size. Different liquids, such as liquid hydrogen, can also be used.

Another important, recent development is the polarized proton beam. In it, the protons have spins all in the same direction. The achievement is equivalent to the polarization of light, in which the light's vibrations are all in one direction, rather than randomly distributed.

• RADIO

Saturday, May 28, 1955, 5:00-5:15 p.m., EDT

"Adventures in Science" with Watson Davis, director of Science Service, over the CBS Radio Network. Check your local CBS station.

Dr. Gordon H. Strom, professor of aeronautical engineering, New York University, will discuss "Air Pollution."

Every atomic nucleus, as well as individual particles, spins on its axis. In an unpolarized proton beam, the axes point every which way. To polarize the beam, protons are hurled at a target of hydrogen, beryllium or carbon. By choosing only those protons that ricochet at a rather small angle, the particles with axes pointed in the same direction are selected.

The protons lose energy when they smash into the target, but if they have high enough energies, the bombardment and selection process can be repeated to get a purer polarized beam. So far scientists have managed to analyze the particles produced after a beam has gone through three targets, known to the scientists as triple scattering. They have also learned to tell whether the axis is pointed "up" or "down."

Although man is reaching higher and higher energies in atom smashers such as needed to polarize protons, even the most powerful machines are only now beginning to rival the low end of the cosmic rays that bombard the earth from outer space.

Photographs of nuclear collisions in cloud chambers located high in the mountains or installed in balloons and airplanes catch tracks of some of these. Emulsions such as used in ordinary photographic film are also a valuable tool for spying on cosmic rays and particles resulting from accelerator smash-ups.

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GENERAL SCIENCE

Science Prexies Over 50

➤ IF YOU have aspirations of becoming president of a professional society, you'll most likely have to wait until your fifties to be elected.

This is the conclusion of Dr. Harvey C. Lehman, professor of psychology at Ohio University, who has compiled the chronological ages at which individuals have first been elected presidents of 68 well-known national learned, scientific and technical societies.

Although professional prestige may be attained at any age level from the twenties to the late eighties, Dr. Lehman discovered, "the fifties are predominantly the years during which both men and women are most likely to become presidents of their professional organizations."

In his study, Dr. Lehman found that although the names of the former presidents of women's societies could be obtained, "the attempt to find their birth dates was not particularly successful." He reported that "a disconcerting number of women who have achieved contemporary eminence and whose names appear in biographical directories have failed to give their birth dates."

Dr. Lehman also found that:

1. There is no correlation between sizes of memberships and the average ages of the presidents.

2. Youthful presidents are elected more often by professional groups that include a large proportion of research workers rather than those whose members are chiefly practitioners.

3. There is a tendency for older professional societies to elect older presidents, and newly-founded groups, relatively youthful presidents.

4. That the average ages of society presidents are influenced by method of election, the society's membership policy and factors influencing the cost to the president in time and money.

The Ohio psychologist's findings led him to conclude that although presidents of such groups "are a very able and fine group of men, it nevertheless seems clear that sheer professional merit, in the narrow sense of the term, is not the sole factor that determines whether or not an individual is destined to become the president of his professional group." Dr. Lehman reported his study to *Scientific Monthly*, journal of the American Association for the Advancement of Science.

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