Antiproton-proton collisions at CERN

There is a curious imbalance in the structure of the earth, the solar system, even our whole galaxy. They are all composed of matter. That statement is not a tautology. The equations of theoretical physics specify that material structures are twinned like left hand and right hand. For every basic kind of particle that exists there exists also a related one with certain basic properties reversed, a kind of mirror image. The mirror images are called antiparticles. In spite of the pejorative-sounding name they are just as material, just as obedient to the laws of physics and have just as much right to exist as the ones we call particles. It is only that for some reason antiparticles are virtually nonexistent in our corner of the universe. The reason eludes cosmologists, and that circumstance causes them grief whenever they remember to think of it.

Now it is announced by the CERN laboratory in Geneva that physicists on earth have managed to make enough of a basic form of antimatter, antiprotons, to accelerate them in a synchrotron originally built for protons and run them into a colliding beam apparatus, where they were collided with an oppositely moving beam of protons. This proton-antiproton collision, or annihilation reaction, is the goal of the effort. It is a fundamental piece of physics, and the things that come out of it are expected to be an entirely new proving ground for the basic theory of the structure of matter that physicists have been evolving over the last two decades.

Although antiprotons hardly exist naturally in our neighborhood, they can be made by certain high-energy processes. They must then be accumulated, grouped into bunches and induced to move in unison. The CERN Antiproton Accumulator succeeded in doing that at the end of last summer. During the winter, beams of antiprotons were taken from the AA and accelerated to various energies in the Proton Synchrotron (which happens to be the instrument with which the laboratory started nearly 20 years ago). The numbers of antiprotons involved in each test run to the tens of billions, which is substantial considering how hard they are to make and how diligently they have to be protected from premature meetings with any of the astronomical number of surrounding protons and thereby undergoing an annihilation reaction too soon. The energies to which they are accelerated range up to 24 billion electron-volts. According to the April CERN Courier this achievement makes the Proton Synchrotron the world's first antiproton synchrotron.

Then, on April 10, antiproton beams that had been led from the Proton Synchrotron into the Intersecting Storage Rings were collided there with a beam of protons. Several groups of physicists had detectors placed to record what happened in the collisions. The data are being analyzed. Results are not available yet.

This is the first reported achievement of proton-antiproton collisions. A few other laboratories in the world are working toward this goal, but they lack CERN's highly satisfactory budget arrangements.

Proton-antiproton collisions are a parallel to the electron-positron collisions available at a number of laboratories all over the world, but they are expected to provide a different dimension in experimental physics. The CERN management keeps referring to proton-antiproton collisions as the first matter-antimatter collisions. That would be correct if the definition of matter is restricted to objects built out of quarks. And that is the important point. It is quarks and the force between them that are the basis of the developing unified theory of microscopic matter.

A proton is supposed to be made of three quarks, an antiproton of three antiquarks. In the collision these structures meet with high energy, and possibly interpenetrate. There may be direct insights into the behavior of the force that binds the quarks in these structures. There may be direct quark-antiquark reactions. Much has been learned about quarks from the electron-positron collisions and much may still be learned, but in a somewhat indirect way. The directness and intimacy of the proton-antiproton collisions is expected to yield information unobtainable otherwise. □

Clean-up microbes for the environment

Designing bacteria to degrade toxic chemicals in soils and waters is one of the more speculative goals of sophisticated genetic engineering. Next month the Environmental Protection Agency will hold a workshop to consider the feasibility of such projects. But a University of Illinois bacteriologist already has been successful in creating bacterial strains that degrade such problem chemicals as 2,4,5-T (found in Agent Orange) and certain chlorinated biphenyls. Ananda M. Chakrabarty — the scientist whose bacterium was the basis of the recent landmark patent case (SN: 6/21/80, p. 387) — did the work. Instead of manipulating the genetic material, Chakrabarty takes advantage of the organism's natural tendency to evolve ways of breaking down carbon-containing molecules and using them as an energy source.

In the 30 years that chlorobenzenes have been used as herbicides, a few microorganisms have evolved ways of degrading them, and Chakrabarty has found that the genes microbes use to break down chlorobenzenes are located on a plasmid, an independent ring of genetic material. Bacteria that degrade dichlorobenzene compounds have the necessary genes on two plasmids.

"It has been hard on the bugs to do it, but they did it," Chakrabarty says. To degrade a simple chlorobenzene takes eight to ten new enzymes, he explains. At each early step in the breakdown of the molecule, the presence of the chlorine atom necessitates that the bacteria use a different enzyme than they would to degrade non-chlorinated benzene derivatives.

From where do the genes come that give bacteria these new capabilities? In nature, they come from other plasmids. The plasmid required to degrade chlorobenzene, for example, seems to have evolved by combining fragments from at least three other plasmids. The second plasmid of bacteria that degrade dichlorobenzene compounds comes predominately from the chlorobenzene-degradation plasmid, but with one fragment from another natural bacterial plasmid.

In the breakdown of chlorinated biphenyls a combination of microbes can be used. Chakrabarty mixes together microbes that convert the chemicals into chlorobenzene compounds and microbes that can degrade chlorobenzenes. Together they grow well and degrade essentially all the chlorinated chemical.

"It is possible in the laboratory to extend the substrate range of a bug as long as you help by supplying plasmid genes and provide pressure," Chakrabarty says. No microorganisms have been found in nature able to break down 2,4,5-T, a chemical found in Agent Orange, says Chakrabarty. But this, he says, is because the chemical is present at such a low level in the environment that bacteria have no incentive to use it as a carbon source. "If we wait for levels where the bugs have such an incentive, it will be too late. We wouldn't be around," he says.

Chakrabarty didn't wait. He mixed together microbes from various waste dump sites and other microbes with a broad assortment of plasmids. During the first week of growth, the plasmids moved into the dump site microbes. Then Chakrabarty added more and more 2,4,5-T to the medium and decreased the supply of other carbon sources. After several months he found that some microbes could survive on the 2,4,5-T.

Chakrabarty envisions releasing such microorganisms into Love Canal, army bases and other areas contaminated with toxic wastes. He expects the plasmids that allow for 2,4,5-T degradation to be transferred naturally to other bacteria in the ecosystem. The same strategy of supplying genes to bacteria and selecting those that acquire a desired function should allow development of other useful waste-eating strains. "As we collect more and more plasmids it will be easier to develop microorganisms that degrade other compounds," Chakrabarty predicts. □