SCIENCE NEWS OF THE WEEK

Antiprotons On A Leash

There is an old, and by now somewhat battered, principle of physics that says that there is as much antimatter as matter in existence. But on earth we see little or no antimatter. We are all matter here, and what antimatter we get is mostly made in the laboratory.

When we make antimatter we have to be extremely careful with it, and do whatever we were going to do with it quickly. Our world is extremely alien to antimatter, and it soon meets its opposite number in matter, and then — poof — to paraphrase the famous poem, all the rest is gamma rays.

At the CERN laboratory in Geneva they have managed to keep a beam of antiprotons going for 85 hours. Considering the keeping time of antimatter in most laboratories, that in itself is an achievement, but how and why they did it is even more important. It was done in a storage-ring device called ICE, and the purpose is eventual matter-antimatter, that is, proton-antiproton collisions in CERN's Intersecting Storage Rings, which would be an achievement with open-ended possibilities for particle physics.

To establish and manage a beam of antiprotons for so long — their energy was 2 billion electron-volts, which is modest, but a good start — is an achievement that might be called a breakthrough or a triumph if those words weren't so worn and ragged. It is, shall we say, noteworthy. One of the serious technological problems in the way of this achievement and an even stronger hindrance to future successes, is what is called beam cooling.

The engineers would like the antiprotons to move around the ring in tight dense little bunches but the antiprotons all have the same, negative, electric charge, and the mutual repulsion among them tends to blow up the bunches. The motion engendered by the electrical repulsion is similar to heat, so the techniques of removing it are called cooling. CERN's method is called "stochastic cooling" and involves very quick feedback between the antiproton bunches and the electronics that control the magnetic fields that focus the bunches. The importance of cooling may be why the device is called ICE.

Manipulating antiprotons in this fashion is something accelerator physicists have simply never done before. CERN says it is the first time that antimatter has been stored. This seems to forget that positron beams are routinely stored and manipulated at a number of laboratories around the world. Possibly CERN doesn't consider positrons to be antimatter. However, antiprotons are 1,800 times as heavy as positrons and vastly more complex physically. Their management is an achievement of a different order. Referring to this as "taming antimatter" seems just.

Once you have the antimatter tamed, you make it do tricks. The first thing physicists will want to study is the physical characteristics of the antiproton itself. It is supposed to be the mirror image of the proton, but its characteristics have been hard to find out.

The stability of the antiproton will probably be the first question. Cosmologists have a lot of trouble finding room in the cosmos for antimatter — in fact they can't find any. So some of them want to amend the principle of symmetry of matter and antimatter so that even though every act of creation makes equal amounts of matter and antimatter, the antimatter eventually disappears, and our 20-billion-year-old universe comes out almost all matter. To do this requires that, although a proton can potentially last forever, antiproton, after some period of time must decay radioactively into something else. This would prevent the build-up of antinuclei, anti-atoms, antiworlds, and icy Count Anti-Draculas.

So CERN physicists are already studying the lifetime of the antiproton. In 85 hours they have found no contradiction to the principle that the antiproton is as stable as the proton, but they will surely try longer storage times. Then follows the deliberate collision of proton and antiproton. The annihilation of matter and antimatter is also a creation event: Given enough energy, all sorts of unusual things can be made. A couple of new chapters in physics have been opened by positron-electron experiments. Proton-antiproton ones are expected to produce even more interesting things. Theorists have a shopping list. We are about to see whether they have anticipated correctly. ☐

What's par for a black hole?

Never in the history of mankind have so many spent so much effort for so little. One might insult the memory of Winston Churchill with a sentence like that. The little is almost nothing. In fact it is nothing, as nothing as you can get scientifically and still have something to talk about. It is a black hole. And a goodly number of observing astronomers are looking for one. More now than ever before. And every one of them would like to be the first to have a generally accepted and properly certified one to his or her credit. It's getting the certification that's going to be difficult.

Black holes are theoretically a derivation of Einstein's equations of general relativity. They represent the ultimate in gravitational crushing — of space and time as well as matter. In a black hole space goes off the edge, time stops and matter vanishes never to return. (Or to return totally transformed — there's a death and rebirth school here, too.) Altogether the subject seems to be a cosmic graveyard, and so it looked for more than half a century after Karl Schwarzschild mathematicized the first black hole onto paper. But then astronomers began to realize that black holes would cause severe disturbances in the space around them. Now it seems that almost any disturbed-looking astrophysical phenomenon is being hung on a black hole. As Herbert Friedman of the Naval Research Laboratory puts it, "The search for conclusive proof of the existence of black holes has become a major endeavor of the entire astronomical community."

The latest piece of evidence offered concerns globular clusters of stars. These are dense associations of stars, up to hundreds of thousands of stars per cluster, that hang like liquid drops in the space surrounding our galaxy. They seem to contain the oldest stars associated with the galaxy.

Some of the clusters emit X-rays, both steadily and in bursts, and it has been suggested that black holes in the centers of the clusters may be responsible. The black hole would draw matter from nearby stars, and, as that matter fell down the hole, it would form a disk or sphere around the hole. Friction would heat the sphere till it gave off X-rays.

Equipment flown on the International Ultraviolet Explorer satellite operated by a group led by Andrea Dupree and Herbert Gursky of the Harvard-Smithsonian Center for Astrophysics has now found evidence for concentrations of bluish stars near the centers of six clusters. Concentrations of this kind can be evidence for a very massive object in the center, and Gursky takes the next step in the ritual by suggesting that such massive objects could be black holes.

A similar line of reasoning was used by the groups of astronomers who postulated a possible black hole in the center of the galaxy M87 (SN: 5/13/78, p. 308). That supermassive black holes may be responsible for the fireworks at the centers of quasars and active galaxies is a proposal of several years' vintage. M87 is the first galaxy about which a detailed observational argument has been made. Meanwhile, back in the Milky Way, as Friedman points out, there is still no good evidence for a black hole in the middle. The center