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.

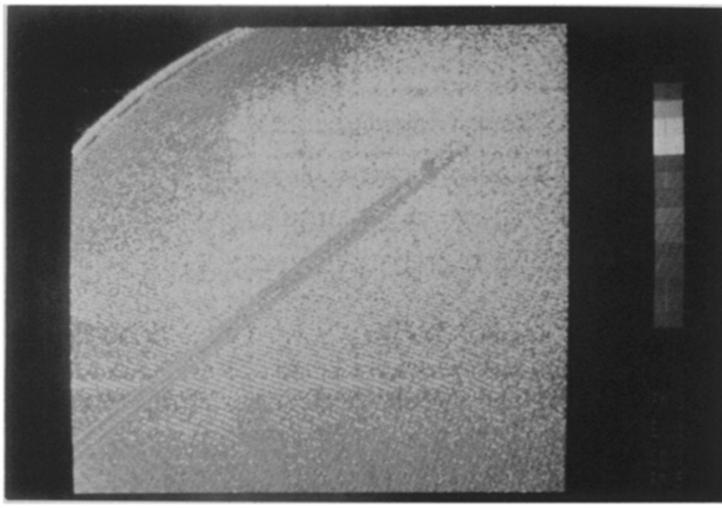
Black holes are theoretically a derivation of Einstein's equations of general relativity. They represent the ultimate in gravitational crushing — of space and time as well as matter. In a black hole space goes off the edge, time stops and matter vanishes never to return. (Or to return totally transformed — 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



Ultraviolet spectra (the thin lines) reveal presence of hot objects that may be due to a black hole.

NASA

of our galaxy is a strong source of radio waves, which led to the suspicion of a black hole, but a Naval Research Laboratory rocket found no evidence of X-rays from Sagittarius A West, the major radio source. Although there are ways to have a black hole without the customary X-ray emission, Friedman says, "The NRL study of the galactic center offers no support for the idea of a massive black hole."

The nearest nonsatellite galaxy to our own is the Andromeda spiral. George Carruthers of NRL looked at the center of the Andromeda galaxy in the ultraviolet, seeking a bright center that might be evidence of black hole activity and found none. So the galaxy count is one maybe yes, two maybe no.

That's the point. It's always maybe. On the globular clusters Gursky cautions that further studies of the dynamics of the stars and how they orbit the centers of the clusters are necessary. The astronomers who observed M87 are very cautious and precise in everything they say, and their colleagues, though respecful of the work, are not organizing any parades. Asking around at a meeting of people interested in quasars, SCIENCE NEWS was told, "It depends on how they used the virial theorem," which, translated, amounts to a more complex version of Gursky's caveat.

Yet in their heart of hearts, each observing group involved in these searches would like to be the one to come home with what Friedman calls "conclusive evidence." Only what will it conclude? Given that a black hole can never be directly seen, what data will convince the majority of astronomers? And will it ever come? □

Enigmatic magma in the Pacific

"You can't always get what you want," say the lyrics of a well-known rock song, "but if you try sometimes, you just might find you get what you need."

The Rolling Stones weren't talking about science, but they could have been — as researchers of the *Glomar Challenger*'s most recent voyage will tell you. The scientists on Leg 61 of the Deep Sea Drilling Project didn't get what they wanted, but, true to the song, they got what they needed — a find that "may well be the major enigma in plate tectonics theory and western Pacific geology" of the next several years, according to co-chief scientist Roger L. Larson.

The purpose of the cruise was fairly routine. Well-substantiated magnetic anomaly mapping of the Nauru Basin near the Marshall and Caroline islands predicted that sediments and ocean crust dating to the Late Jurassic (about 150 million years ago) existed there. Researchers picked the basin as a perfect spot to retrieve a continuous fossil and sediment record of the equatorial Pacific Ocean Basin and to sample the old, rapidly generated ocean crust. Drilling at only a single site, they ground through the expected layers of chert, clay, sandstone and black shales, anticipating only more sediment before striking crust. Instead, the *Challenger*'s drill dug through 500 meters of a "huge, completely unexpected volcanic structure."

The 100-million-year-old volcanic complex—a mixture of basaltic sills, flows and volcanic sediments—represents a geologically quick (lasting about 10 million years) outpouring of magma that may cover the entire 500-by-1,000-kilometer basin. Mid to late Cretaceous sediment deposits from the nearby island reefs coincide in age with the volcanic complex, disputing the islands' supposed formation about 50 million years ago. This indicates, says Larson, that the "volcanic underpinning [of the islands] is the result of the culmination of this volcanic event."

More fundamental than pondering the islands' origin, researchers have to explain how the huge pile of mid-Cretaceous basalt got there. Similar intrusive sills are found throughout the Pacific, Larson says, but they range only 1 to 10 meters thick and are easily detected because they disrupt the underlying layers' magnetic signal. A volcanic outpouring of such size should have reheated the crust, allowing the realignment of the magnetic anomaly pattern, and should also have physically dislocated the underlying rock. But this magma mass did neither, and its uniform magnetic anomaly pattern amidst the Late Jurassic signal made it "invisible" to the magnetometer.

Larson says there are no clues as yet to explain the way the complex got there without disturbing the magnetic signal, but it seems, he says, that "you have to bring [the magma] through the Jurassic basement." Any model will have to meet peculiar thermal requirements.

As for Leg 61's original, frustrated effort: "It's always nice to find what you predicted," Larson says. "But this is how you keep your strength up in this business.... You might not look so smart in that you didn't predict it, but you found something new,... completely unexpected." □

They vant to be alone

Back in the days when radio astronomy was new, people interested in the possibility of intelligent life on other planets suggested using radio telescopes to look for evidence of such life. The suggestion was that such intelligent beings might be looking for company and sending out signals. It was proposed that such signals might come on the frequency naturally emitted by atomic hydrogen. Clouds of atomic hydrogen pervade the galaxy, and it was reasoned that any civilization with radio astronomy would have found the 21-centimeter radiation and have receivers tuned to it.

A number of searches have been made under such an assumption, all negative. The most recent, which looked at 200 stars near to us and similar to the sun (the most likely kind of stars for having planets) with the earth's most sensitive radio receiver, the Arecibo radio telescope, has found no evidence of such signals, Paul Horowitz of Harvard University reports in the Aug. 25 SCIENCE.

The search was made under the assumption that any interested aliens would be beaming a recognition signal toward our sun and that they would be doing it at a frequency suitably redshifted so that it would reach our receivers at that of atomic hydrogen at rest in the laboratory. It thus appears that there is no evidence for creatures that are doing this on those 200 putative solar systems. That may mean there are no creatures. Or it may mean that they are not intelligent enough to know about radio, or they are not interested in sending recognition signals to particular stars. Or maybe they have chosen not to broadcast at all. Maybe they just vant to be left alone in their suite in the cosmic Grand Hotel. □