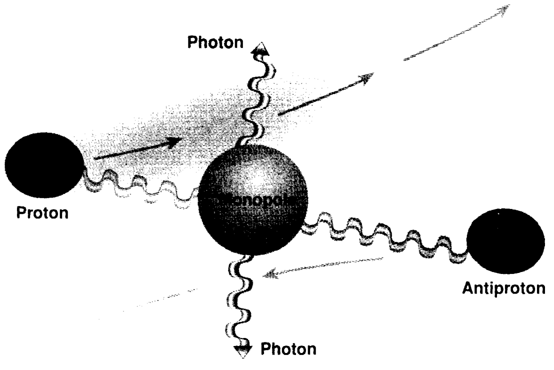
PHYSICS

A Giant Snare for Monopoles

Physicists have spent a lot of time looking for magnetic monopoles. They have good reasons to believe in the reality of these particles—the equivalent in magnetism of the fundamental bits of electric charge carried by electrons. And the existence of a single unit of magnetic charge would help answer some deep and nagging questions such as why the proton and electron have exactly the same amount of electric charge.

But monopole searchers have had no luck. For instance, they have not found monopoles embedded in ancient rock from the moon, and they have not seen them float through detectors in the lab. Now physicists have looked for monopoles with the world's highest energy accelerator and, again, have come up spectacularly empty. The nondiscovery, now in press at *Physical Review Letters*, puts some new limits on the mass of this aspiring particle and has also sparked a bit of a debate about how to look for it.

Most searches have looked for monopoles that may have been drifting through the universe since the beginning of time. "There's every reason to expect they were produced in the big bang," says Jeffrey Harvey, a physicist at the University of Chicago. The traditional way to look for these relic monopoles is with a loop of wire. If a monopole passes through, it induces a distinct blip of current in the wire, which can easily be detected. But such efforts have yielded nothing except for one 1982 sighting now viewed as a fluke. Many physicists suspect that the big bang made only a small number of monopoles, which are now too scattered to be easily detected.



Little big bang. If colliding protons spawned a monopole, a pair of high-energy photons (green) might reveal it.

The "little bangs" created when particles collide in an accelerator, however, might also spawn monopoles, which could pop in and out of existence, influencing the energy or direction of the debris from the collision. In 1995, physicists looked for hints of monopoles made by colliding electrons and positrons at the Large Electron-Positron Collider at CERN, near Geneva, but found none.

Thinking that higher energy collisions might improve the odds, Ilya Ginzburg, a theorist at the Institute of Mathematics in Novosibirsk, Russia, mentioned in a recent colloquium at the Fermi National Accelerator Laboratory, in Batavia, Illinois, that it should also be possible to observe monopoles in the collisions of protons and antiprotons in Fermilab's Tevatron accelerator. The monopoles, he and a colleague calculated, could boost the energy of photons produced in the collisions. "The idea was so new and interesting," says Fermilab's Greg Landsberg, "I got really excited."

So Landsberg and colleagues on the D0 Experiment went back and sifted through the data from millions of collisions. They looked for pairs of high-energy photons emerging at large angles to the collision. Sadly, Landsberg says, "we found none." The effort wasn't all for naught, however. To have escaped detection, certain types of monopoles would have to have a relatively large mass—in one case, more than 1580 times that of a proton.

This new technique of trolling for monopoles has drawn some criticism. Kimball Milton and his colleagues at the University of Oklahoma, Norman, contend that monopole theory isn't far enough along to calculate reliably whether monopoles would really have this kind of effect. Milton prefers a more direct approach. If the monopoles are light (less than several hundred times a proton's mass), he says, it's possible that they are literally streaming out of the collisions and lodging in the detector. Milton and colleagues have gotten Fermilab to ship them bits of old detectors, which are passing through loops of wire to search for monopoles. "The odds are slim," he admits, but if they find one, they'd have it for keeps. "We'd be rich and famous."

–David Kestenbaum

PHYSICS

Putting Antimatter on the Scales

One of the bearing walls of modern physics is that particles of antimatter and those of matter are perfect counterparts, down to their mass. That wall is standing strong, according to new results presented last week at a meeting of the American Physical Society's Division of Atomic, Molecular, and Optical Physics in Santa Fe, New Mexico. The international team has caged a proton and an antiproton in a trap and deduced that they have the same mass to within a part in 10 billion.

Joe Lykken, a theoretical physicist at the Fermi National Accelerator Laboratory in Batavia, Illinois, notes that although the existing theory of particles and forces insists on mass equivalence, a speculative alternative called superstring theory may allow a small difference in mass. So Harvard University physicists Gerald Gabrielse, Anton Khabbaz, and David Hall, along with collaborators from the University of Bonn in Germany and elsewhere, decided to check. The team caught a single antiproton from the LEAR accelerator at Europe's CERN laboratory near Geneva in a web of electric and magnetic fields, where it spun in circles like a firefly in a jar. The researchers also introduced a negative hydrogen ion (a proton with two electrons circling it) into the same trap. Protons and antiprotons have opposite charges, but the hydrogen ion has the same charge as an antiproton, which makes the two easy to compare.

To see if their masses differed, the team watched how fast the particles raced around inside the trap. If one particle were heavier, it would take a little while longer to make an orbit. They used tiny electrodes to check. "Each time the particle passes one electrode ... it induces a current to pass through a resistor, and that current we amplify and measure," Khabbaz explains.

The group found that the two raced around in almost identical circles, about 100 micrometers across, 90 million times per second. They concluded—after correcting for the tiny mass of the two electrons—that the proton and antiproton have the same mass to about 10 decimal places, a factor of 10 times better than previous measurements. "[The precision of] this result is extraordinary," says Jook Walraven, a physicist at the Institute for Atomic and Molecular Physics in Amsterdam.

The finding by no means rules out string theory, says Lykken: "We are very ignorant about string theory; we don't know how large the string effects may be." He would like to see experiments with an even higher degree of precision: "These experiments don't cost very much money compared to other things you do in high-energy physics, and you have the potential for a spectacular result."

–Alexander Hellemans

Alexander Hellemans is a science writer in Naples, Italy.