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Bell Labs News

The Positron Chase

BY HOLLY BIGELOW

"For every piece of matter in the universe, there can, in theory, be a corresponding piece of antimatter with the same mass, which is opposite in just about every other way," says Cliff Surko, who until recently was head of the Semiconductor and Chemical Physics Research Department at Murray Hill.

When matter and antimatter combine, they disappear, leaving only radiation behind, as required by Einstein's famous equation $E=mc^2$. "It's a little bit like magic, but it works," Surko says.

Scientists at Murray Hill have been looking at this phenomenon for what it can reveal about the nature of the universe. Antimatter particles are hard to study, however, because almost as soon as one comes into existence, it is likely to meet up with its mirror image, causing both to vanish. As a result, scientists could only look at antimatter particles on an individual basis.

But with a new invention by Surko, Marv Leventhal and Al Passner, that's all changed. The group built a 'bottle' which can collect antimatter electrons, or positrons, up to a density where, as Bob Dynes says, "some new and interesting physics can occur." Dynes is head of the Chemical Physics Research Laboratory, which funded part of the experiment.

The result is a positron trap that will eventually be able to catch a billion of the elusive particles, formed by a radioactive source, and hold them together for up to an hour. The trap works by combining two established technologies: the use of thin pieces of metallic foil to slow the positrons down as they pass through, making them easier to grab; and electric and magnetic fields inside a giant coil about six feet long and three feet in diameter, which control the movement of the particles.

"We count the positrons by dumping them onto a metal plate," says Surko. "When a positron hits the metal, it combines with an electron and gives off two gamma rays, which we can detect. So far, a maximum of 300,000 positrons can be confined in a space the size of a plum."

Once the positrons are trapped, the scientists found that they quickly cool to near room temperature. The resulting positron gas is then cold and dense enough to be considered a plasma. "This is the first single-component antimatter plasma created in a laboratory," Surko says. "We expect it to act similarly to electron plasmas, which people have been able to make for a long time. But the creation of a positron plasma will allow us to study many new phenomena, such as waves in plasmas composed of both electrons and positrons.

"The use of positrons to study ordinary matter has a long history at Bell Labs, through the work of Allen Mills, of the Scattering and Low Energy Physics Research Department, and colleagues," says Surko. "Mills has shown that positrons are a nice tool for studying the surfaces of solids and he's been a helpful advisor on our trap experiment."

Positrons may even help us discover how the universe is structured. Leventhal, an astrophysicist in the Scattering and Low Energy Physics Research Department, is interested in using the trapped positrons to study the annihilation radiation when they are put into a fusion plasma. "That process is similar to the astrophysical processes at the center of our galaxy," he says.

Cliff Surko hooks up the positron detector system.

Exploring the fundamental questions of the universe won't be the only benefit of such an experiment. "One of the unsolved problems in a fusion reactor is how the electrons in the fusion plasma leak out of the magnetic field that's holding them together," Surko says. "We realized that you could study the motion of escaping electrons by using positrons, which have the same mass as electrons, as a sort of dye tracer. Our positron trap is a way of accumulating enough positrons to do this."

Surko will be leaving Bell Labs in November to teach physics at The University of California in San Diego, but he and Leventhal will continue to collaborate.

"This positron trap is quite an important step," says Surko. "It establishes our ability to look at positrons collectively, rather than just as isolated particles. We'll be able to take a handful of antimatter and throw some ordinary matter into it, to see how this mixture of matter and antimatter behaves. This will bring us closer to our fundamental understanding of the physical world." ■

Al Passner, of the Semiconductor and Chemical Physics Research Department, helped build the positron trap.

Antimatter Meanings

For those who've forgotten everything they learned in freshman physics, here's a glossary of some of the key terms used in this article:

Antimatter	The mirror image of ordinary matter which, when it comes into contact with ordinary matter, annihilates, leaving only energy in the form of light.
Electron	A fundamental particle of matter that has a negative charge and a small mass.
Fusion	The union of atomic nuclei to form a heavier nucleus, releasing large amounts of energy.
Gamma Ray	A form of light, which is the highest energy radiation in the electromagnetic spectrum.
Magnetic Field	The field around a magnet or a current-carrying wire, which gives rise to a force.
Plasma	A collection of molecules, electrons and the ions that result when molecules are stripped of their electrons. A plasma differs from a gas in that the particles can act collectively to conduct electricity or support a magnetic field.
Positron	A looking-glass version of the electron which has the same mass as an electron but opposite charge.