Antimatter-Matter Mirror Shows Warp

Amid the vast energies and ultrasmall dimensions of particle physics, a looking-glass world of antimatter shimmers into view. In 1964, surprised physicists discovered that this antimatter realm is not a perfect mirror image of the familiar matter-dominated surroundings. Now, for the first time since that revelation 35 years ago, scientists have detected another flaw in the mirror.

"What we have found is a new physical effect in nature," says Bruce Winstein of the University of Chicago. The discovery may help illuminate how the universe went from nearly equal antimatter and matter at its birth to the overwhelming preponderance of matter seen today, the researchers say. It also dashes one theory offered to explain nature's uneven way of dealing with matter and antimatter and bolsters the prevailing theory of particle physics known as the standard model.

Before 1964, physicists assumed that the outcomes of experiments would remain the same if two types of symmetrical particle characteristics were both changed. Under so-called charge, or C, symmetry, particles and antiparticles are interchanged; under parity, or P, symmetry, directions such as clockwise or right transform into their mirror images.

The landmark experiment by James W. Cronin of the University of Chicago and Val L. Fitch, now of Princeton University, and their colleagues revealed that nature—or at least particles called K mesons, or kaons—didn't behave as expected. Cronin and Fitch later shared a Nobel prize for their demonstration that the combined symmetry could break down into a CP violation.

The new finding from Winstein and scores of his colleagues working on the "Kaons at the Tevatron," or KTeV, experiment at Fermi National Accelerator Laboratory in Batavia, Ill., represents the first definitive evidence of another type of CP violation sought since 1964. Fermilab announced the finding on March 1.

"It's a marvelous result," Fitch says.

Researchers at the European Laboratory for Particle Physics (CERN) near Geneva published similar findings in 1988 and 1993, notes Konrad Kleinknecht of the University of Mainz in Germany. However, those results had too much uncertainty to be considered definitive, KTeV researchers say.

Scientists have also reported preliminary indications of a CP violation in experiments with a particle called a B meson (SN: 2/20/99, p. 118).

The new effect, like the 1964 finding, arises in kaons but from a different aspect of their behavior. These particles have an unusual property that enables matter and antimatter forms to intermingle by the rules of quantum mechanics to create blended particles called K-long (K_l) and K-short (K_s). The experimenters observe these particles rather than the pure matter and antimatter.

Theoretical arguments based on CP symmetry demand that K_l should always decay into three other particles, but Cronin and Fitch found that occasionally it would decay into only two particles in what physicists call an "indirect" CP violation.

The Fermilab experiment started with those signature decays of K_l to only two particles. The scientists examined which events produced offspring carrying electric charges and which produced neutral ones. The team then compared those outcomes to the decays of K_s particles. Analysis revealed that about one of every 300 of those K_l decays was a "direct" CP violation that resulted from a process other than the matter-antimatter mixing.

The finding challenges a theory of CP violation that postulates the existence of an extremely weak force of nature, known as superweak. "This throws that scheme out the window," Fitch says.

While the standard model of particle physics predicts direct CP violation, theorists and experimenters have more work to do to determine whether the details of the model agree with the new findings, says Edward C. Blucher, also of the University of Chicago. —*P. Weiss*

Marrow transplant fights bone disease

Children born with a hereditary disease called osteogenesis imperfecta can face a lifetime of bone deformities, fractures, and short stature. These children produce faulty collagen—the white, fibrous protein that forms the framework for bone, tendons, and ligaments.

The skeletons of severely affected children are so weak that parents have been known to break a child's leg accidentally while changing a diaper. There is no known cure for osteogenesis imperfecta. Treatment consists of inserting metal rods into the largest bones as reinforcements.

Now, initial findings in a study of three children with the disease who received bone marrow transplants from healthy siblings reveal sharp increases in the recipients' bone mass, fewer fractures, and some height gain. The work, reported in the March NATURE MEDICINE, raises the prospect of a treatment that attacks osteogenesis imperfecta at its core.

Three months after receiving the marrow transplants, only 1.5 to 2.0 percent of the patients' osteoblasts—cells that make collagen—stemmed from donated marrow. Yet that small amount seems to have made a difference, says study coauthor Edwin M. Horwitz, a pediatric hematologist and oncologist at St. Jude Children's Research Hospital in Memphis, Tenn.

Horwitz admits to being "a bit surprised" when analysis showed that the three children had added 21, 28, and 29 grams of bone in the 100 days after the transplant. Healthy children of these ages—two of the patients were 13 months old and the other 32 months old—showing the same modest weight gain would have been expected to add less than 4 g of bone, he says.

The children chosen for this study were shockingly fragile. One of the 13-month-old infants had already had at least 37 fractures. This baby had only 3 fractures during the 6 months following the marrow transplant. The other 13-month-old baby had had at least 20 fractures before treatment but only 2 during the follow-up period. The third child had had 3 fractures in the 6 months preceding transplant and none during the next 6 months.

During the 6-month follow-up period, the two younger children grew 8.0 and 6.5 centimeters, roughly on a par with healthy babies that age. The older child, who hadn't grown at all during the 6 preceding months, grew 1.5 cm—38 percent of the normal rate.

One in 20,000 babies born in the United States has osteogenesis imperfecta. Those with severe cases—such as the children in the new study—usually don't survive beyond their 20s, Horwitz says. Some with less severe disease live longer, but many need wheelchairs to get around.

Marrow transplants—most commonly used to fight blood cancers and certain genetic diseases—had never been tried against osteogenesis imperfecta for fear that the procedure would place too great a strain on the children. Better transplant techniques have made marrow donation safer, says Stanton L. Gerson, a hematology oncologist at Case Western Reserve University in Cleveland. The treatment seems to work, but until doctors give it to more children, it is "premature to talk about this as a clinical success," he says. —*N. Seppa*