New Experiments Will Shed Light On Matter And Antimatter

July 22 2004

If the laws of physics were precisely the same for matter and antimatter, you wouldn't be reading this. All matter, as we know it, would have been converted into light after the Big Bang. To explore the fundamental differences between matter and antimatter, physicists need a vast amount of data. In early July, the PEP-II accelerator at the Stanford Linear Accelerator Center, one of the world's chief suppliers of these data, reached a new milestone: **It is delivering three times as many particle collisions per second as the machine was designed to produce.**

"This remarkable achievement allows us to perform much more precise measurements that will shed light on matter-antimatter asymmetries," said physicist Marcello Giorgi, a spokesman for the BaBar collaboration, which has just published its 100th paper based on data from PEP-II. "These asymmetries are fundamental features of the laws of nature that played a major role in the evolution of the universe."

The Big Bang, according to the most basic physical laws, created equal amounts of matter and antimatter. Whenever a particle of matter meets its antimatter twin, they annihilate each other, leaving behind only a burst of energy.

The particles of energy photons zipping through the universe today are evidence that a lot of annihilations took place. However, the fact that we are here is proof that the annihilation was incomplete: There is one particle of matter for every billion photons. It's the cause of this one-in-a-billion imbalance that scientists are trying to understand.

Researchers designed PEP-II to collide electrons and their antimatter counterparts, positrons, at the precise energy that produces an abundance of short-lived pairs of particles and antiparticles called B mesons, which decay spontaneously into other particles of matter and antimatter. Because the B meson is relatively heavy, it can decay into matter and antimatter in more ways than lighter particles can. If there were no difference between matter and antimatter, both the B meson and the anti-B meson would decay at exactly the same rate.

Some decay patterns are very rare. The BaBar collaboration has seen some decays only a few times in 10 million events. Were it not for the multitude of B mesons PEP-II is providing, studies of such unusual particle behavior would be impossible.

In addition, a bigger data sample means better results. If you can only flip a penny 10 times and you get heads seven times, you could conclude that it will turn up heads 70 percent of the time. But if you flip the penny 100 times, you're likely to see that heads turns up closer to half the time.

The 600 physicists from around the world in the BaBar collaboration are now working around the clock to see what insights the new data hold. Matthew Graham, a University of Wisconsin postdoctoral fellow, is among those studying a process that caused excitement when a rival collaboration called Belle, which is based at a Japanese accelerator laboratory, announced a result that has just a 1 percent chance of agreeing with the currently prevailing theory, known as the Standard Model. BaBar's result at that time had a 60 percent chance of agreeing with the Standard Model. The discrepancy could simply be due to statistical chance, or it could be much-sought-after evidence of the Standard Model's Achilles' heel.

Both collaborations have significantly more data for this round of analysis, so it wouldn't be a surprise to see the results change when both

collaborations present their latest results in mid-August at the International Conference on High Energy Physics, to be held this year in Beijing.

Ultimately, as Giorgi points out, both collaborations "are on the same adventure. We hope to open a window on new laws of physics."

Relevant Web URLs:

Stanford Report, July 21, 2004: news-service.stanford.edu/news …/luminosity-721.html
BaBar Collaboration Home Page: www.slac.stanford.edu/BFROOT/
BaBar Public Information: www-public.slac.stanford.edu/babar/

Source: Stanford Linear Accelerator Center