SLAC Press Release

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Physicists discover dramatic difference in behavior of matter versus antimatter

EDITORS:

Photographs of the BaBar detector are available at:
http://www.interactions.org/slaccp/

Relevant Web URLs:

Charge Parity Violation:
http://www2.slac.stanford.edu/tip/special/cp.htm
Observation of Direct CP Violation in B0 -> K+pi- Decays:
http://arxiv.org/abs/hep-ex/0407057

Today, physicists conducting the BaBar experiment at the Stanford Linear Accelerator Center (SLAC), a Department of Energy laboratory operated by Stanford University, announced exciting new results demonstrating a dramatic difference in the behavior of matter and antimatter. They submitted their results to the journal Physical Review Letters for online publication.

SLAC's PEP-II accelerator collides electrons and their antimatter counterparts, positrons, to produce an abundance of exotic heavy particle and anti-particle pairs known as B and anti-B mesons. These rare forms of matter and antimatter are short-lived, decaying in turn to other lighter subatomic particles, such as kaons and pions, which are observed in the BaBar experiment.

"If there were no difference between matter and antimatter, both the B meson and the anti-B meson would exhibit exactly the same pattern of decays. However, our new measurement shows an example of a large difference in decay rates instead," said BaBar spokesman Marcello Giorgi,a physicist at Istituto Nazionale di Fisica

Nucleare (INFN) and the University of Pisa.

By sifting through the decays of more than 200 million pairs of B and anti-B mesons, BaBar experimenters have discovered striking matter-antimatter asymmetry. "We found 910 examples of the B meson decaying to a kaon and a pion, but only 696 examples for the anti-B mesons," Giorgi explained.

While BaBar and other experiments have observed matter-antimatter asymmetries before, this is the first instance in B decays of a difference obtained by simply counting up the number of matter and antimatter decays, a phenomenon known as direct charge parity (CP) violation.

"We have observed a clear, strong signal for asymmetrical behavior of matter and antimatter resulting from the direct CP violation mechanism," said James Olsen of Princeton University, one of the leaders of the analysis.

The new observation of a 13 percent preference for the B meson over the anti-B meson dwarfs a similar effect observed in kaons at only a tiny rate of 4 parts in a million. "The effect we have measured with B mesons is roughly 100,000 times stronger than for kaons," Olsen said. "The pattern of different types of matter-antimatter asymmetries is starting to come together into a coherent picture."

When the universe began with the big bang, matter and antimatter were present in equal amounts. But all observations indicate that we live in a universe made only of matter. What happened to the antimatter?

Subtle differences between the behavior of matter and antimatter must be responsible for the matter-antimatter imbalance that developed in our universe. But our current knowledge of these differences is incomplete and insufficient to account for the observed matter domination. CP violation is one of the three conditions outlined by Russian physicist Andrei Sakharov to account for the observed imbalance of matter and antimatter in the universe.

"This is another great scientific achievement for the B-factory at SLAC," said Raymond L. Orbach, Director of the Department of Energy's Office of Science. "The new result from BaBar, and related

measurements at other accelerators around the world, continue to improve our understanding of CP violation and ultimately may tell us why the visible universe is only matter."

"The new measurement is very much a result of the outstanding performance of SLAC's PEP-II accelerator and the efficiency of the BABAR detector," Giorgi said. "The accelerator is now operating at 3 times its design performance and BaBar is able to record about 98 percent of collisions."

"This is an exciting and beautiful result—it probes a key mechanism underlying the structure and behavior of matter," said SLAC Director Jonathan Dorfan. "The observation of the direct CP violation effect in B decays is a significant step forward in assembling the pieces of the puzzle of matter versus antimatter."

SOME 600 SCIENTISTS AND ENGINEERS FROM 75 INSTITUTIONS IN CANADA, CHINA, FRANCE, GERMANY, ITALY, THE NETHERLANDS, NORWAY, RUSSIA, THE UNITED KINGDOM, AND THE UNITED STATES ARE WORKING ON BABAR. SLAC IS FUNDED BY THE DEPARTMENT OF ENERGY'S OFFICE OF SCIENCE.

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-By Neil Calder

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