

***BABAR* studies matter-antimatter asymmetry in τ lepton decays**

Humans have wondered about the origin of matter since the dawn of history. Physicists address this age-old question by using particle accelerators to recreate the conditions that existed shortly after the Big Bang. At an accelerator, energy is converted into matter according to Einstein's famous energy-mass relation, $E = mc^2$, which offers an explanation for the origin of matter. However, matter is always created in conjunction with the same amount of antimatter. Therefore, the existence of matter – and no antimatter – in the universe indicates that there must be some difference, or asymmetry, between the properties of matter and antimatter.

Since 1999, physicists from the *BABAR* experiment at SLAC National Accelerator Laboratory have been studying such asymmetries. Their results have solidified our understanding of the underlying micro-world theory known as the Standard Model. Despite its great success in correctly predicting the results of laboratory experiments, the Standard Model is not the ultimate theory. One indication for this is that the matter-antimatter asymmetry allowed by the Standard Model is about a billion times too small to account for the amount of matter seen in the universe. Therefore, a primary quest in particle physics is to search for hard evidence for “new physics”, evidence that will point the way to the more complete theory beyond the Standard Model.

As part of this quest, *BABAR* physicists also search for cracks in the Standard Model. In particular, they study matter-antimatter asymmetries in processes where the Standard Model predicts that asymmetries should be very small or nonexistent. Such a process is the radioactive decay of the tau (τ^-) lepton – a massive cousin of the electron – or its antiparticle, the τ^+ . These studies can be performed only at electron-positron *B*-factories, where copious production of easily identified $\tau^+\tau^-$ pairs takes place. *BABAR* has collected 437 million $\tau^+\tau^-$ pairs.

In a [paper](#) submitted recently to the journal *Physical Review D*, the *BABAR* collaboration reports a measurement of such an asymmetry: the difference between the probability for a τ^- to decay into a particular set of particles and the probability for a τ^+ to decay into the corresponding set of antiparticles. The Standard Model prediction for this asymmetry is 0.36% with an uncertainty of 0.01%. Carefully accounting for the makeup of the data sample and the different interactions of the matter and antimatter final-state particles with the detector material, *BABAR* found an asymmetry of 0.45%, with a total uncertainty of 0.26%. This corresponds to a three-standard-deviation discrepancy between the theoretical and experimental values.

Discrepancies of this magnitude are rare enough to be intriguing and to warrant further study, but are not large enough to constitute discovery of new physics. A similar measurement from the Belle experiment should shed some light on whether the discrepancy may be due to new physics or is a statistical fluctuation. This question will ultimately be resolved by the next generation of approved *B*-factory experiments – Belle-II in Japan, and the Italian experiment SuperB, which will reuse many of the components of the *BABAR* detector and its accelerator.