CP Violation

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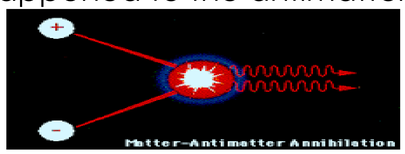
Abstract

My research focused on antimatter and different theories related to the antimatter matter asymmetry after the Big Bang. To understand this, I studied CP violations in Kaons and B mesons. I also studied the research collected in space by the AMS-02.

Introduction

Our universe is composed of matter. However when the universe was created during the Big Bang, both matter and antimatter were created. We have not detected antimatter in our observable universe, which is beneficial as the contact of matter with antimatter would result in annihilation--the release of high amounts of energy in the form of light (photons). Scientists must now determine what happened to the antimatter.

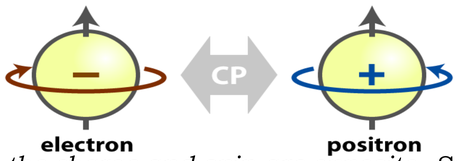


[1.]

This is a picture of a matter antimatter collision (annihilation) the result is a release of a large amount of energy in the form of photons.

What is CP violation?

CP violation relates to the lack of antimatter (shares same characteristics as matter except it has an opposite charge) in the universe. It is theorized that when the universe was created, equal amounts of both matter and antimatter were created. CP is the combination of 2 symmetries: charge conjunction and parity. CP violation is when the CP symmetry is broken between matter and antimatter during decay.

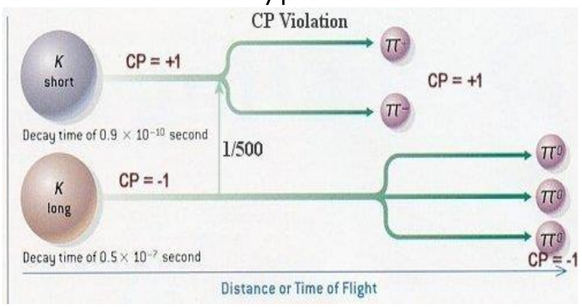


[2.]

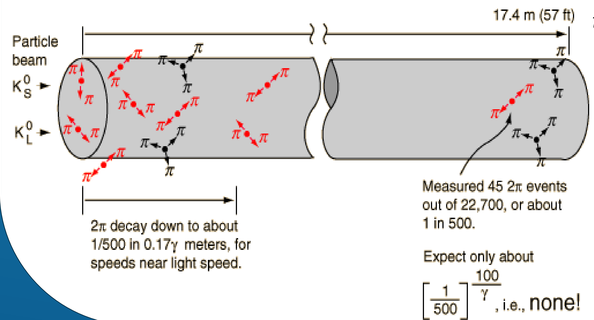
Notice the charge and spin are opposite. So in the picture the CP is symmetrical.

Kaon

Kaons are a type of meson always made of an anti-strange and an up quark. There are 2 types: K-long and K-short; these decay into Pions. In an experiment done by Cronin and Fitch, Kaons were shot into a 57-foot pole and Pions were observed on the other end. They discovered 1out of every 500 Kaon decays showed some type of CP violation [9.].



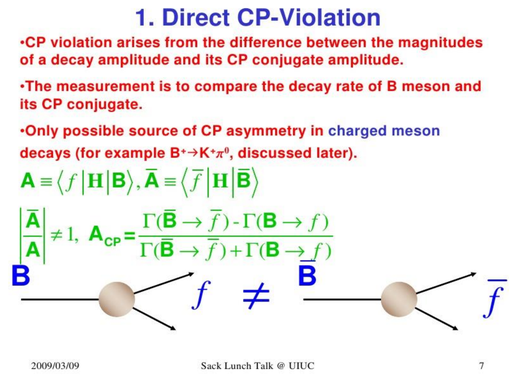
[3.] *The picture to the left shows the decays of the two types of Kaons. Notice only the K long can show types of CP violation.*



[4.] *The picture to the left shows the Cronin and Fitch experiment.*

B Meson

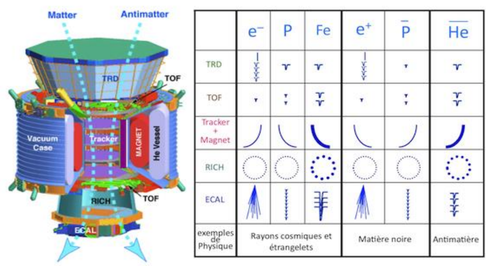
B Mesons are composed of a bottom and an anti-strange quark.
These Mesons can oscillate between matter and antimatter. This behavior, named flavor oscillation, was discovered in the CDF experiment at Fermi Lab. During flavor oscillation, CP symmetry is not always conserved, which is a CP violation [11.].



[5.] *This picture shows that when the B Meson switches from matter to antimatter CP symmetry is not conserved.*

Alpha Magnetic Spectrometer-02

The AMS-02 is a powerful cosmic ray detector onboard the International Space Station that has recorded over 18 billion events. It uses large magnetic fields to detect particles moving at approximately the speed of light. It is used to detect antimatter, anti-Helium Helium flux, and dark matter rays [10.]. The data it collects will have great significance for future cosmic research.

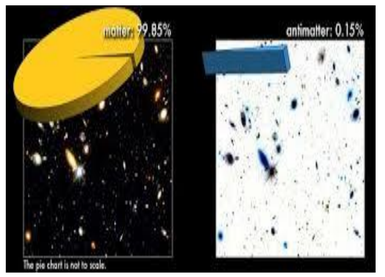


[6.] *This is a picture of the AMS detector and the different types of paths the particles take inside the detector.*

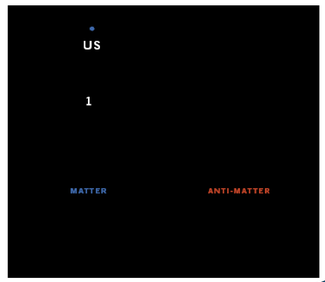
3 Asymmetry Theories

1. After the Big Bang, slightly more matter was created vs. antimatter; and after annihilation, only matter remained to create our universe. [7.]

2. There are distant galaxies beyond our observable universe made entirely of antimatter. [8.]



3. CP violation resulted in the existence of more matter vs. antimatter. [7.]



References

1. "Strange Quarks." Jinaweb.org. Web. 6 Aug. 2015. <http://www.jinaweb.org/outreach/PAN_ND2013/Gamma.pdf>.
2. "Quantum Diaries." Quantum Diaries RSS. Web. 6 Aug. 2015. <http://www.quantumdiaries.org/2009/09/28/symmetry-in-physics-pt-2-discrete-symmetries-and-antimatter/>.
3. "CP Violation." CP Violation. Web. 6 Aug. 2015. <https://universe-review.ca/R02-14-CPviolation.htm>.
4. "Cronin and Fitch Experiment with Kaons." Cronin and Fitch Experiment with Kaons. Web. 6 Aug. 2015. <http://hyperphysics.phy-astr.gsu.edu/hbase/particles/cronin.html>.
5. "CP Violation in B Meson and Belle." CP Violation in B Meson and Belle. Web. 6 Aug. 2015. <http://www.slideshare.net/pinghan/cp-violation-in-b-meson-and-belle>.
6. "The Alpha Magnetic Spectrometer - About AMS-02." The Alpha Magnetic Spectrometer - About AMS-02. Web. 6 Aug. 2015. <http://ams.nasa.gov/about.html>.
7. "Well Spent Journey." Well Spent Journey. Web. 6 Aug. 2015. <https://wellspentjourney.wordpress.com/tag/robert-jastrow/>.
8. "HubbleSite - Out of the Ordinary...out of This World." HubbleSite - Out of the Ordinary...out of This World. Web. 6 Aug. 2015. <http://hubblesite.org/>.
9. Christenson, J. H., J. W. Cronin, V. L. Fitch, and R. Turlay. "Evidence for the 2 π Decay of the K 2 0 Meson." Phys. Rev. Lett. Physical Review Letters (1964): 138-40. Print.
10. Accardo, L et al . "High Statistics Measurement of the Positron Fraction in Primary Cosmic Rays of 0.5–500 GeV with the Alpha Magnetic Spectrometer on the International Space Station." Phys. Rev. Lett. Physical Review Letters 113.12 (2014): n. pag. Web.
11. Macfarlane, David B. "Measurement of CP-Violating Asymmetries in B0 Decays to CP Eigenstates." Physical Review Letters (2001). Print.
12. Sakharov, Andrei D. "Violation of CP in Variance, C Asymmetry, and Baryon Asymmetry of the Universe." Soviet Physics Uspekhi Sov. Phys. Usp. (1991): 392-93. Print.

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