Matter/Antimatter Asymmetry

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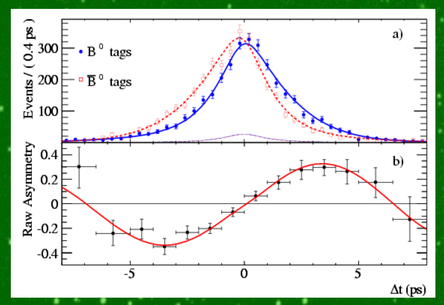
CP Violation

C: Charge Conjugation- every charged particle has an oppositely charged antimatter counterpart, or antiparticle
P: Parity- the reflection in the origin of the space coordinates of a particle or particle system

CP violation is the violation of the conservation laws, charge conjugation (C) and parity (P), by the weak nuclear force, which is responsible for reactions such as the decay of atomic nuclei (the symmetry between matter and antimatter is imperfect).



The figure shows the measured time difference (Δt) distributions when the tag meson decayed as a B (in blue) and as a B-bar (in red). The blue and red distributions are slightly different. This small difference is an example of CP Violation.

According to the Standard Model, CP violation occurs in the weak interaction, more specifically when quarks undergo weak interactions and turn into quarks with different electric charge.

CKM (Cabbibo-Kobayashi-Maskawa) Model

Specifies the mismatch of quantum states of quarks when they take part in weak interactions.

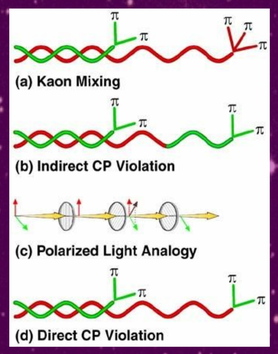
Predicts that the asymmetry in the B-meson decay will be between 0.7% and 0.8%.

The CKM model cannot entirely explain the matter/antimatter asymmetry present in the universe.

Kaon Decay

Fitch and Cronin observed that both neutral kaons decayed into $\pi\square$ and $\pi\square$. This would be impossible if CP was in good symmetry.

The Kaon is electrically neutral and decays half the time to three other mesons called pions. Under CP conservation this meant that the Kaon should not decay to two pions. What was found was that it does decay to two pions, at a rate of about two in a thousand (0.2%).



Overview

Immediately following the Big Bang, all matter and antimatter began annihilating, however for every billion particle-antiparticle pairs there was one extra particle. These extra particles created the universe as we know it.

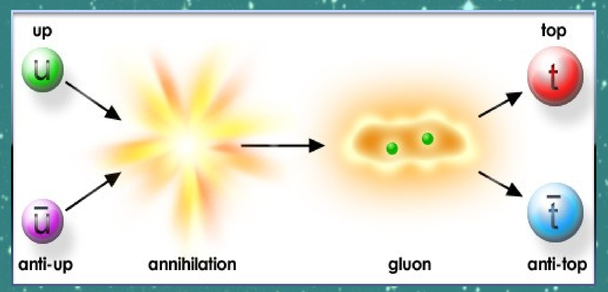
What is Antimatter?

Antimatter is material composed of antiparticles, which have the same mass as particles of ordinary matter but have opposite charge. Also, the spin in relation to the magnetic field is reversed.

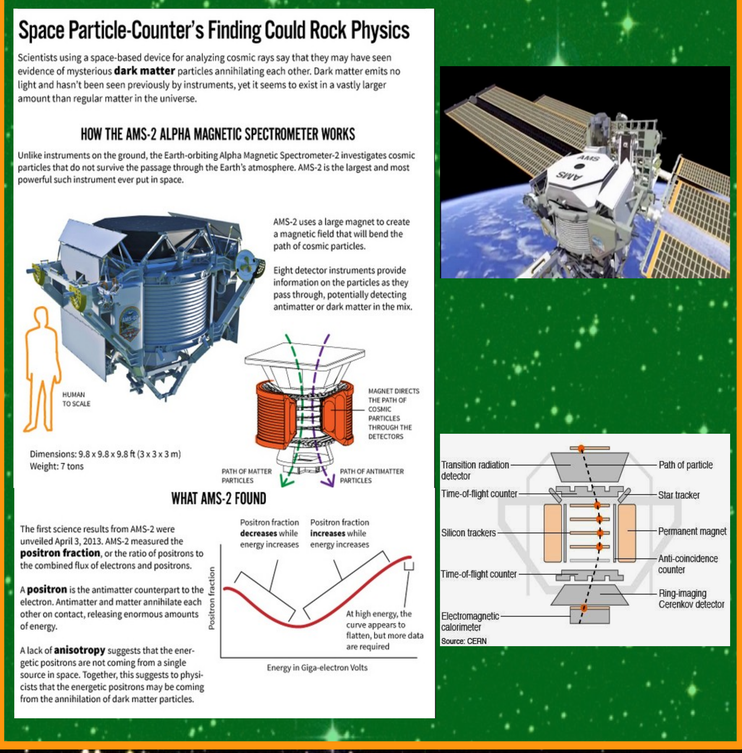
Particle	Antiparticle
Electron	Positron
Proton	Antiproton
Neutron	Antineutron

Annihilation

Particles interact with each other, converting the energy of their previous existence into a very energetic force carrier particle. These force carriers, in turn, are transformed into other particles.



The Alpha Magnetic Spectrometer (AMS)



Important Experiments on Matter/Antimatter Asymmetry

Experiment	Accelerator	Laboratory	Location
BaBar	PEP-II	SLAC	Stanford
Belle	KEKB	KEK	Tsukaba
CDF	Tevatron	Fermilab	Batavia

*Tevatron was closed in 2011

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