

Antimatter

Just as the equation  $x^2=4$  can have two possible solutions ( $x=2$  OR  $x=-2$ ), so Dirac's equation could have two solutions, one for an electron with positive energy, and one for an electron with negative energy.

Dirac interpreted this to mean that for every particle that exists there is a corresponding antiparticle, exactly matching the particle but with opposite charge. For the electron, for instance, there should be an "antielectron" called the positron identical in every way but with a positive electric charge.



# History of Antimatter

$$\gamma \rightarrow e^{+} + e^{-}$$

1928 Dirac predicted existence of antimatter

1932 antielectrons (positrons) found in conversion of energy into matter

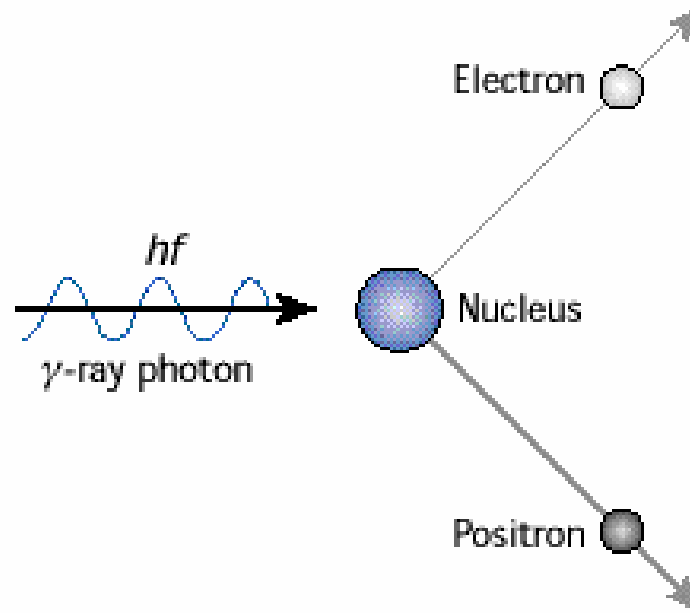
1995 antihydrogen consisting of antiprotons and positrons produced at CERN

In principle an antiworld can be built from antimatter

Produced only in accelerators and in cosmic rays

# Pair Production

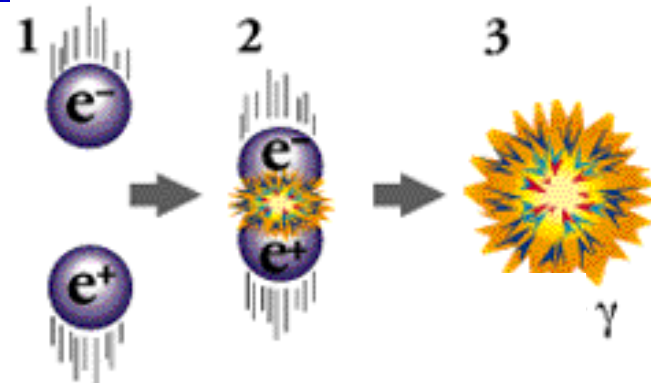
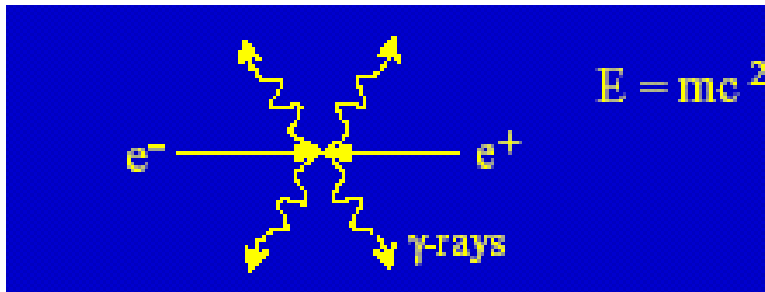
$$\gamma \text{ rays} \rightarrow e^{+} + e^{-}$$



Equal amounts of matter and antimatter are produced  
if energy is converted to matter

# Annihilation

$$e^+ + e^- \rightarrow 2hf$$



Antimatter can be produced.  
It annihilates with matter to produce energy.