Particles 003 Particles and Anti Particles

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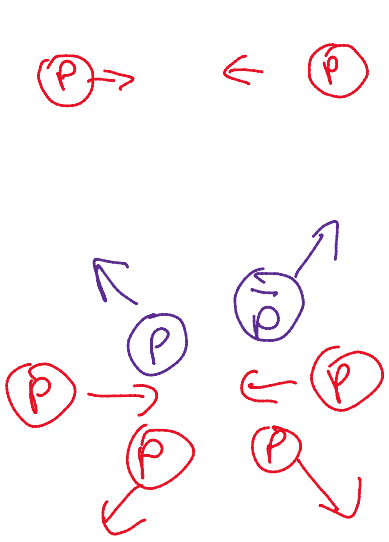
All particles (neutrons, electrons, sigma, pions etc have an antiparticle. Same rest mass, and rest energies .... opposite charge (and other things)

Oddly mass and energy are very closely related - we talk about their 'equivalence' - so the Rest Energy is the equivalence in energy of the mass. This is the basis of $E=mc^2$

Energy can get converted into mass....



Two fast moving p^+ collide... creating a lots of energy

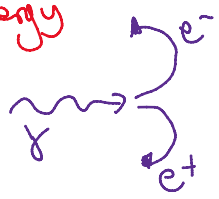
You get the original 2 protons & another proton & an anti proton

This production of an additional p and $\bar{p}$ Is an example of 'pair production' and often consists of a particle and its anti-particle.

Pair Production and Photons

Pair production happens when a photon has enough energy to create the masses of the particle/antiparticle pair. Usually only gamma ray photons have enough energy. It is more common to get electron/positron pairs since these have lower mass.

E_0 = rest energy



The gamma needs to have enough energy to make $2 \times E_0$

Most often Pair Production occurs near nuclei ~ to preserve momentum.

$E_{min} = hf_{min} = 2E_0$

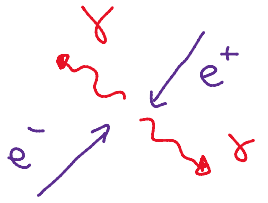
Annihilation

The opposite of pair production - when an antiparticle and a particle collide (after all, they are oppositely charged...) All the mass tied up in the two particles is converted back into energy - you

guessed it, as gamma rays

In this case both will have a minimum energy which when added together equals (at least) $2E_0$

$2E_{min} = 2E_0 \Rightarrow E_{min} = hf_{min} = E_0$



momentum has to be conserved

Example

An electron and its anti-particle are produced from a photon. Rest mass of an electron is 9.11×10^{-31}Kg. Find the maximum wavelength of the photon.

$c = f\lambda$

$\therefore f = \frac{c}{\lambda}$

Answer:

The anti particle is the positron and it has the same rest energy as the electron. The photon therefore needs to provide the two lots of E_{rest} for the electron.

So...

$E_{photon} = 2E_{rest} = 2mc^2$

$E_{photon} = hf \Rightarrow E_{photon} = \frac{hc}{\lambda}$

$\frac{hc}{\lambda} = 2mc^2 \Rightarrow \frac{h}{2mc} = \lambda$

So $\lambda_{max} = 1.2 \times 10^{-12}$ m

Why max – what happens is λ is longer?