Particle Interactions

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An interaction describes a collision between two particles resulting in new particles being formed, or a decay of an unstable particle into other particles.

Collisions

When particles collide, the total energy that they contain is their and the energy that they have due to . After the collision, the particles produced may have different and energies, but the total must remain the same ( ). This means that we can produce different particles by collisions.

e.g.

$$\mathrm{p} + \mathrm{p} \longrightarrow \mathrm{p} + \mathrm{n} + \pi^{+}$$

The collision of two protons gives and a pi-plus. Some of the kinetic energy of the protons goes into producing the extra mass of the and pion.

Decays

Most particles are , which means that they decay into other particles (similar to radioactive decay). A particle will decay into other particles as long as the total mass of the products is less than the , so that any excess mass will go into the of the products.

e.g.

$$\pi^{+} \longrightarrow \mu^{+} + \nu_{\mu}$$

mass of $\pi^{+} = 2.5 \times 10^{-28}$ kg
mass of $\mu^{+} = 1.9 \times 10^{-28}$ kg
mass of ν_{μ} is almost zero ($< 3.4 \times 10^{-34}$ kg)

All unstable particles have a characteristic , which is the average time that it will take for that particle to decay.

Conservation laws

In every interaction:

1. must be conserved
2. must be conserved
3. must be conserved
4. must be conserved
5. must be conserved
6. strangeness S
   (a) is conserved in collisions
   (b) changes by in a weak decay

Notes

- Strange particles decay by strong or weak decays, and these can usually be distinguished by the lifetime of the decay (the typical lifetimes for strong decays are typically 10^{-23} s, and weak decays typically 10^{-8} s). Strangeness may be 'lost' in a weak decay: no strange particles are stable, and when one decays, the strangeness can change by ± 1, so that the total strangeness gets closer to zero. Although strangeness can change in this way in weak decays, in strong decays of strange particles, strangeness **is** conserved. We shall presume all strange decays to be weak, i.e. strangeness will change if a strange particle decays, as a strange quark changes into a non-strange quark.

- Energy/mass considerations will not be taken into account, as in principle any energy can be converted into mass in accelerators.

The general method of solution is to write Q, B, L, S below the interaction and check for conservation.