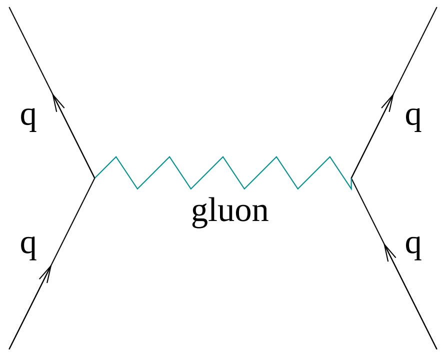
Bosons

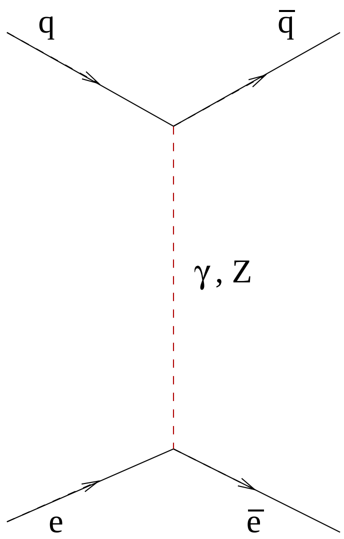
particle	spin ($\hbar$)	mass	interaction
graviton	2	0	gravity
photon	1	0	electro-magnetism
Z	1	91 GeV/c^2	weak interaction (neutral)
$W^{\pm}$	1	80 GeV/c^2	weak interaction (charged)
gluon	1	0	strong interaction (color)
(Higgs boson)	0	≥ 114 GeV/c^2	superweak

Bose particles are quanta of radiation fields

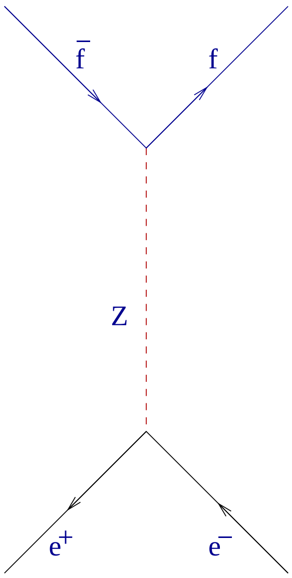
$\longrightarrow$ transmit forces between particles.

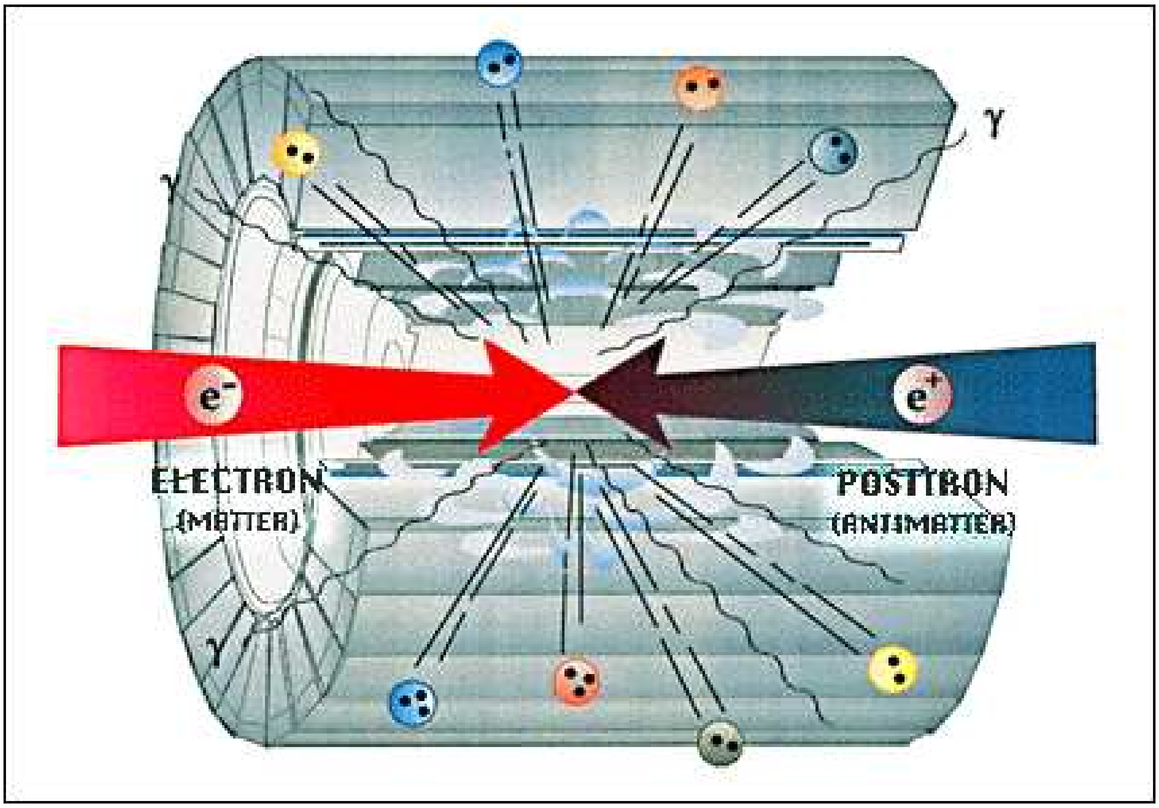


1.Strong force: scattering of two quarks by exchange of a gluon.

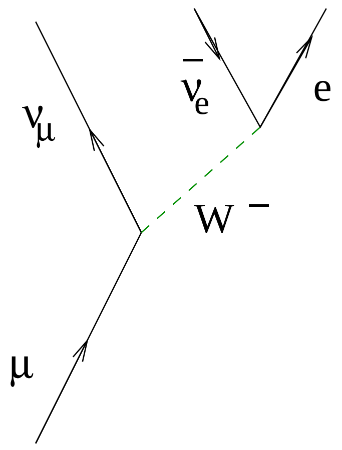


2.Creating matter out of energy: Annihilation of an e^+e^--pair followed by the creation of a quark/anti-quark pair via production of a foton (γ) or a (Z) boson.

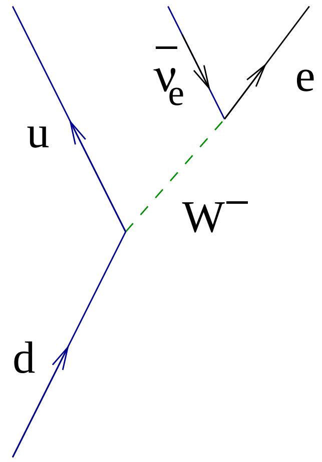

$\bar{f}$
f
Z
e^+
e^-


γ
e^-
e^+
ELECTRON
(MATTER)
POSITRON
(ANTIMATTER)

Weak interactions



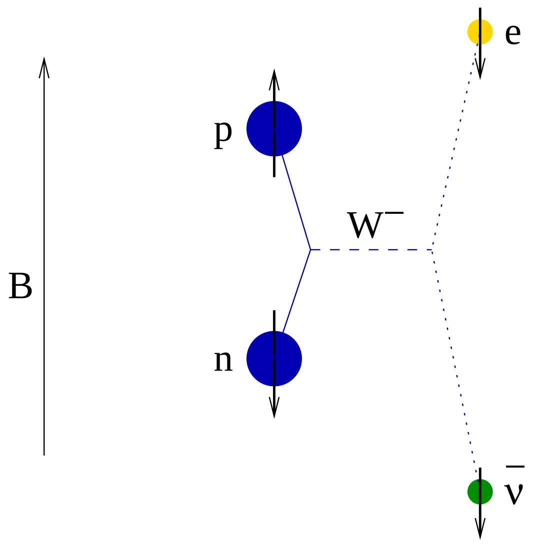
3. Muon decay via exchange of a W-boson.



4. d-quark decay via exchange of a W-boson.

Parity violation

The weak interactions distinguish intrinsically between left and right in nature: they violate parity symmetry.



The classical experiment is β-decay of polarized nuclei; the electron always comes out with its spin anti-parallel to its momentum; by conservation of angular momentum the anti-neutrino always has its spin parallel to its momentum.

Conclusion:
all neutrino's produced in weak interactions are left-handed.

Parity violating structure of the weak interactions:

- The charged $W^{\pm}$-bosons couple *only* to left-handed particles.
- The neutral Z-boson couples *predominantly* to left-handed particles (quarks and leptons).

Electro-magnetic interactions:
- The photon γ couples *equally* to left- and right-handed particles.

Both Z and γ are electrically neutral vector particles
$\longrightarrow$ one can make linear combinations

$$W^0 = Z \cos\theta - \gamma \sin\theta, \qquad B = Z \sin\theta + \gamma \cos\theta,$$

such that the W^0-boson couples *only* to left-handed particles; then B couples to *both* left-and right-handed particles, but with different strength.

The effective coupling of the neutral W^0-boson to left-handed particles then is exactly *equal* to that of the charged $W^{\pm}$-bosons.