

Lectures 1/2

Constituents of matter (“first generation”)

up quark	u	anti-up	\bar{u}
down quark	d	anti-down	\bar{d}
electron	e^-	positron	e^+
neutrino	ν_e	antineutrino	$\bar{\nu}_e$

Carriers of forces

strong (nuclear)	gluon	g
electromagnetic	photon	γ
weak (nuclear)	vector bosons	W^\pm, Z^0
	Higgs boson	H

Leptons: only EM or weak interactions: e, ν

Hadrons: strongly interacting, built out of quarks

- **baryons:** 3 quarks
proton, p ; neutron, n (nucleons, N)
- **mesons:** quark+antiquark
pions, π^{\pm}, π^0
- **exotics?**

Feynman diagrams

Represent process by drawing line for each particle involved

Joined by vertices representing interactions

Conserve charges at every vertex

Fermions: arrows follow “flow” of charge

Sensible units

Energies in multiples of eV: MeV (10^6), GeV (10^9), TeV (10^{12})

Masses in “natural units”: MeV/ c^2 , GeV/ c^2

Lengths in: fm (10^{-15} m or 1 fermi)

Two very useful constants

$$\hbar c \simeq 200 \text{ eV nm} = 200 \text{ MeV fm}$$

$$\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} \simeq \frac{1}{137}$$

Exchange forces

Exchange of a virtual particle of mass $M \rightarrow$ force with range

$$R \simeq \frac{\hbar}{Mc}$$