

Particle Physics → pag. 161.gov

Structure of Matter

- Elementary particles: smallest possible pieces

Composite Particles: $p, n, \text{ nuclei}, \pi, \rho, \omega, \phi, \eta, \eta'$
 $\Delta^+, \Sigma, \text{ baryon}$ meson
 Fermions boson
 $S = \frac{1}{2}, \frac{3}{2}, \dots$ $S = 0, 1, \dots$

Elementary Particles: no internal structure

Particle
 lepton
 fermion
 $S = \frac{1}{2}$
 Antiparticle
 e^- e^+
 ν_e^- $\bar{\nu}_e$
 ν_μ^- $\bar{\nu}_\mu$
 ν_τ^- $\bar{\nu}_\tau$

e^- , up, down make up atoms on earth

$e^-, \nu_e, \bar{\nu}_e, e^+$ in sun

$P = \overset{\text{up}}{u} \overset{\text{up}}{u} d$
 $N = u d d$

quark
 $S = \frac{1}{2}$
 make up composite particles
 up $\frac{2}{3}$ \bar{u}
 down $-\frac{1}{3}$ \bar{d}
 charm $\frac{2}{3}$ \bar{c}
 strange $-\frac{1}{3}$ \bar{s}
 top $\frac{2}{3}$ \bar{t}
 bottom $-\frac{1}{3}$ \bar{b}

- leptons + quarks obey Pauli E.P.

- $S = \frac{1}{2}$ objects not easily compressed

- all have different masses

- mass of nucleon comes largely from relativistic mass

- $\frac{1}{2}$ mass comes from kinetic E

- $\frac{1}{2}$ mass comes from binding E

- Weak IA + weak charge can distinguish b/w left-handed particle + right-handed particle

$-\frac{1}{2}$ - Left-handed particle: direction of spin opposite motion

$+\frac{1}{2}$ - Right-handed particle: direction of spin same as motion

- Weak IA not mirror-symmetric

- Single quarks do not exist because color charge is so strong
- can't see color charge
- different colors always attracted to each other

3RD kind of charge: color charge

- Red, Green, Blue

* red green blue
- $p = \text{red } u \text{ green } u \text{ blue } d$

- every quark comes in 3 colors

- leptons don't have color

- What kind of quark, anti?, l/r-handed, color

- If quark is L, anti-quark is R

- Each color has anti-color, quarks carry anti-color

Bosons S=1

More color charge \rightarrow More interaction with gluons

Field Quantize

EM: γ photon

Weak:

More $e^- \rightarrow$ More interaction

$d \rightarrow u + e^- + \bar{\nu}_e$

w/EM field

W^+, W^-, Z^0

Have Mass (heavy)

Strong IA

Act like "glue"

8 Gluons: carry 2 charges: color + anti-color

Mesons: 1 quark + 1 anti-quark

$\pi^+ : u\bar{d}$

Baryon: 3 quarks

$\pi^0 : u\bar{u}$

STANDARD MODEL: describes everything in observable universe

- can make predictions, eg. magnetic dipole moment

Lagrangian = Recipe

Higgs Boson: very heavy particle (2ND heaviest)

- Everything gets mass because of interaction w/ Higgs Field

- More IA \rightarrow more mass

- Quantum Chromodynamics