

Elementary particles

Fermions

- $\frac{1}{2}$ ℏ spin, ℏc int
- obey Pauli exclu^s°

Bosons

- ℏ spin
- don't obey Pauli exclu^s°

hadrons

grouped into fams
meson nonets

$$(ex) \bar{u}d \rightarrow \pi^+$$

$$\begin{aligned} 3q \text{ or } 3\bar{a}-q \\ uuu \rightarrow \Delta^{2+} \\ uud \rightarrow \Sigma^0 \\ sss \rightarrow \Omega^- \end{aligned}$$

baryons

mesons

quark - antiquark pair

$$\frac{\bar{u}\bar{d}}{\sqrt{2}} \rightarrow \pi^0$$

leptons

- point-like
- composite

electron e^-
 e^- neutrino ν_e

muon μ^-
 μ^- neutrino ν_μ

tau τ^-
 τ^- neutrino ν_τ

all have
antiparticles

Lepton n^-

up	$+\frac{2}{3}$	} basic pair
down	$-\frac{1}{3}$	
strange	$-\frac{1}{3}$	} heavier
charm	$+\frac{2}{3}$	
bottom	$-\frac{1}{3}$	} heavier
up	$+\frac{2}{3}$	

Decay

Mesons \rightarrow leptons / photons

Baryons \rightarrow $\begin{cases} p \text{ (or } \bar{p}) \\ \text{leptons} \\ \text{photons} \end{cases}$

Baryon n^-

$$\beta = \frac{1}{3} (\bar{N}/q) - \bar{N}(\bar{q}))$$

$$\begin{cases} L_e = N(e^-) - N(e^+) + N(\nu_e) - N(\bar{\nu}_e) \\ L_\mu = N(\mu^-) - N(\mu^+) + N(\nu_\mu) - N(\bar{\nu}_\mu) \\ L_\tau = N(\tau^-) - N(\tau^+) + N(\nu_\tau) - N(\bar{\nu}_\tau) \end{cases}$$

Dimens's

Atomic

$$1\text{Å} = 10^{-10} \text{ m}$$

$$\sim 10^{-18} \text{ s}$$

$$m_e = 0.511 \text{ MeV}/c^2$$

$$10 - 1000 \text{ eV}$$

Vs

$$\begin{matrix} \text{Length} \\ \text{Time} \end{matrix}$$

$$m_e = 0.511 \text{ MeV}/c^2$$

Nuclear

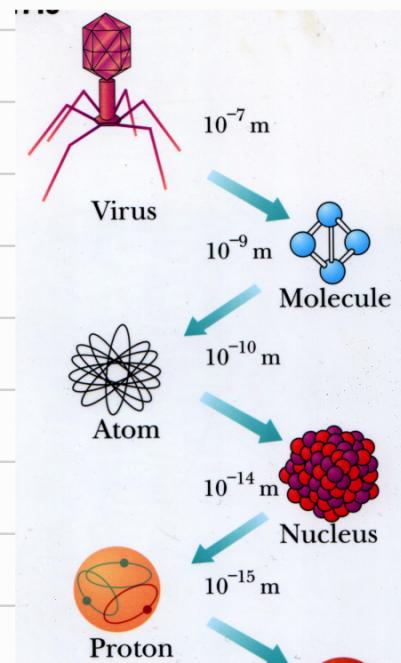
$$1\text{fm} = 10^{-15} \text{ m}$$

$$\sim 10^{-17} / 10^{-23} \text{ s}$$

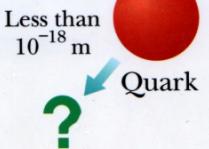
$$m_p = 938.3 \text{ MeV}/c^2$$

$$m_n = 939.6 \text{ MeV}/c^2$$

$$1-10 \text{ MeV}$$



4 Forces



- 1) Gravity Graviton acts on all m/e $\propto \frac{1}{r^2}$
- 2) Electromagnetic Force photon acts b/w electrically charged part $\propto \frac{1}{r^2}$ (10^{-16} s)
- 3) Weak force bosons W^+, W^-, Z^0 hadrons/leptons experience it 10^{-18} m $>10^{-12} \text{ s}$
- 4) Strong force Gluon acts on quarks, not leptons $\propto \frac{1}{r^2}$ $\sim 10^{-15} \text{ m}$ $\sim 10^{21} \text{ s}$
color charge (q_1, q_2, q_3)
+ Spring-like
holds hadrons & nuclei together

Weak vs Strong

$$Fr^2 \ll t_{fc} \quad Fr^2 \gg t_{fc}$$

