

## 0. The standard model

3 kinds of elementary particles: leptons, quarks, mediators (bosons)  
 six leptons: classified based on charge, electron num ( $L_e$ ) muon number  $L_\mu$  and tau number ( $L_\tau$ )

	$l$	$Q$	$L_e$	$L_\mu$	$L_\tau$
first gen	$e$	-1	1	0	0
	$\bar{\nu}_e$	0	1	0	0
second generation	$\mu$	-1	0	1	0
	$\bar{\nu}_\mu$	0	0	1	0
third generation	$\tau$	-1	0	0	1
	$\bar{\nu}_\tau$	0	0	0	1

+ 6 anti leptons with all signs reversed:  
 positron:  $Q = +1$   $L_e = -1$

$\Downarrow$   
 12 leptons

## 6 flavours of quarks

classified by charge, strangeness  $S$ , charm:  $C$ , beauty  $B$ , truth  $T$   
 "upness"  $U$ , "downness"  $D$  - not used often  $\rightarrow$  redundant terms

also 3 generations:

	$q$	$Q$	$D$	$U$	$S$	$C$	$B$	$T$
1st	$d$	-1/3	-1	0	0	0	0	0
	$u$	2/3	0	1	0	0	0	0
2nd	$s$	-1/3	0	0	-1	0	0	0
	$c$	2/3	0	0	0	1	0	0
3rd	$b$	-1/3	0	0	0	0	-1	0
	$t$	2/3	0	0	0	0	0	1

+ antiquarks with all signs reversed

+ 3 colour options

$\Downarrow$   
 36 quarks

3 generations represent increasing mass

+ 12 mediators:  $\gamma$  + 8 gluons +  $W^\pm$  +  $Z^0$  + Higgs

# 1) Particle physics

Book: David Griffiths: Introduction to Elementary Particles

## Elementary particle dynamics

The four forces:

	Strength	Theory	Mediator
Strong	10	chromo-dynamics	gluon
Electromagnetic	$10^{-2}$	electrodyn.	Photon
Weak	$10^{-13}$	flavour dyn.	W and Z
Gravitational	$10^{-42}$	geometrodynamics ↓ general relativity	graviton

↕  
how do particles interact with each other

↕  
quantum + relativity

↕  
quantum field theory

weak force:  $\beta$  decay, decay of the  $\pi$ ,  $\mu$  and many of the strange particles

↳ the theory is sometimes called flavour dynamics or  
Glashow-Weinberg-Salam (GWS) theory

↕  
treats weak and electromagnetic interactions as a form of  
a single electroweak force  $\Rightarrow$  instead of 4  $\rightarrow$  3 forces

Strong force: chromo dynamics

$\rightarrow$  mediated by particle exchange

$\rightarrow$  strong nuclear force between two protons is in reality a complicated interaction between 6 quarks