## Particle properties [cf PPB]

1. Additive quantum numbers
2. mass
3. statistics
4. spin
5. intrinsic magnetic moment

(6. multiplicative quantum nos. : C, P, T)

# 1. Additive quantum numbers

- conserved
- quantized
- antiparticles have opp. qu. nos.

[[ don't use q (quark) or Q (energy released) ]]

## a) Electric charge

quantized in units of $e = 1.6 \times 10^{-19}$ C for observable particles

leptons: $\nu$ neutral
$e^-, \mu^-, \tau^-$ have charge $-e$

quarks: $u, c, t$ have $\frac{2}{3}e$ [not observable]
$d, s, b$ have $-\frac{1}{3}e$

hadrons: baryons $qqq$ have $2e, e, 0, -e$
mesons $q\bar{q}$ have $e, 0, -e$

force carriers: $\gamma, g, Z^0$, graviton are neutral
$W^\pm$ have $\pm e$

Higgs: neutral

[why quantized? Dirac: magnetic monopoles
+ QM $\Rightarrow$ quantization of charge.
No monopoles detected.
Some GUTs predict supermassive monopoles.]

b) Baryon # : conserved by all four forces of standard model
[but possibly violated BSM]

quarks: $A = \frac{1}{3}$
antiquarks: $A = -\frac{1}{3}$
everything else $A = 0$

$\Rightarrow$ baryons: $A = 1$
mesons: $A = 0$

c) Lepton # : conserved by standard model
[$e^- e^- \to \pi^- \pi^-$ never observed]

leptons: $L = 1$
antileptons: $L = -1$
everything else: $L = 0$

Any particle that is its own antiparticle must be neutral wrt all additive quantum nos.

$\gamma$, $Z^0$, graviton; $\pi^0$

not $n$, [$A = 1$]
not $\nu$ [$L = 1$]