Lecture 5/6

Charge conjugation

Replace every particle by its antiparticle

Assuming Hamiltonian is unchanged $\rightarrow$ C parity conserved
C: multiplicative quantum number

Neutral particle can be own antiparticle $\rightarrow$ intrinsic C parity
Photon: $C = -1$ (quantum nos often written J^{PC}, eg γ: $J^{PC} = 1^{--}$)

Particle-antiparticle state with relative orbital angular momentum L and total spin S:

$$C = (-1)^{L+S}$$

P, C conserved by strong and EM interactions but not by weak

Time reversal

Reverses direction of time

Momentum **p**, angular momentum **J** both odd under T

Quantum field theories symmetric under $CPT \rightarrow$ antiparticles

Spin and statistics

Identical particles: wave functions either even or odd under exchange

- integer spin, π, γ, H, ..., even: bosons
- half-integer spin, e, p, q, ..., odd: fermions

Two identical spin-$\frac{1}{2}$ fermions: spin state is odd if $S = 0$, even if $S = 1$
(and spatial state must have opposite symmetry)

Quark model (for matter as we know it)

Quarks: spin-$\frac{1}{2}$ fermions with charges

	B	Q	I_3
u	$+\frac{1}{3}$	$+\frac{2}{3}$	$+\frac{1}{2}$
d	$+\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{2}$

$(Q = \frac{1}{2}B + I_3)$

Antiquarks: reverse all signs

Hadrons

mesons	$q\bar{q}$	$B = 0$
baryons	qqq	$B = +1$
antibaryons	$\overline{qqq}$	$B = -1$

Colour: 3-valued charge

- quarks: r, b, g; antiquarks: $\bar{r}$, $\bar{b}$, $\bar{g}$
- hadrons: colour singlets

Baryon colour wave functions: odd under exchange

Parity

- mesons: $P = (-1)(-1)^L$ ($q\bar{q}$ pair odd)
- baryon ground states: even (excited states: complicated)

C parity

- neutral mesons: $C = (-1)^{L+S}$

Isospin multiplets

Particles with different charges, masses differing by only few MeV distinguished by values of I_3 (counts nos of u, d quarks)

$I = 0$	singlet	ω
$I = \frac{1}{2}$	doublet	$(p,\ n)$
$I = 1$	triplet	$(\pi^+,\ \pi^0,\ \pi^-)$
$I = \frac{3}{2}$	quartet	$(\Delta^{++},\ \Delta^+,\ \Delta^0,\ \Delta^-)$

3rd component: $I_3 = +I, \ldots, -I$ (like angular momentum)