Lecture 9

Particles Interactions

"Quantum Field Theory in a week"

Summary From Last Time

Massive:

$|P,\sigma\rangle$ and $U[\Lambda]\,|P,\sigma\rangle = \sum_{\sigma'} R_{\sigma,\sigma'}\,|\Lambda P,\sigma'\rangle$, where the R is a rotation matrix.

Massless:

$|P,h\rangle$ and $U[\Lambda]\,|P,h\rangle = e^{ih\Theta(W)}\,|\Lambda P,h\rangle$, where the coefficient is just a phase.

Now talk about all these particles states in a more convient way.

For every given momenta we have stacks of Hilbert space

- infinitely many possibliities for Bosons $0 \to N$
- fixed number (depending on the spin) for fermions

Ultimately interested in the interactions between partilces.

- Defined by some Hamiltonian
- Could specify the Hamiltonian by describing how it acts on all states in the Hilbert space
- Instead for our convience introduce creation and anhilation operators These keep track of teh states in a simple way...

First define the vacuum state: $|0\rangle$. Then define single particle states as:

$$\underbrace{|P\sigma\rangle}_{\text{These are primary}} \equiv a^{\dagger}_{p\sigma}\,|0\rangle$$

This defines $a^{\dagger}_{p\sigma}$.

$$|P_1\sigma_1, P_2, \sigma_2\rangle = a^\dagger_{p_1\sigma_1} a^\dagger_{p_2\sigma_2} |0\rangle$$

etc. etc. etc.

Similarly, can define anhilation operators

$$\begin{aligned} a_{P,\sigma} |0\rangle &= 0 \\ a_{P,\sigma} |P, \sigma\rangle &= |0\rangle \end{aligned}$$

a - removes states.

Can encode boson/fermion statistics in a and $a^\dagger$.

Bosons	Fermions
$[a^\dagger_{P_1,\sigma_1}, a^\dagger_{P_2,\sigma_2}] = 0$	$\{a^\dagger_{P_1,\sigma_1}, a^\dagger_{P_2,\sigma_2}\} = 0$
$[a_{P_1,\sigma_1}, a_{P_2,\sigma_2}] = 0$	$\{a_{P_1,\sigma_1}, a_{P_2,\sigma_2}\} = 0$