4/26/16 Lecture 9 outline / summary

• $P_{L,R} = \frac{1}{2}(1 \mp \gamma_5)$, Mass terms mix helicity, massless fermions can have well-defined helicity: $\mathcal{L} = \bar{\psi}(P_L^2 + P_R^2)(i\partial\!\!\!/ - m)\psi = \bar{\psi}_R i\partial\!\!\!/ \psi_R + \bar{\psi}_L i\partial\!\!\!/ \psi_L - m\bar{\psi}_R\psi_L - m\bar{\psi}_L\psi_R$.

• QED: seems the electron is a Dirac Fermion, with both helicities, since it is massive. Actually, the electron is chiral; this is seen when E+M are unified with the weak force. All of the known fermions of the SM are chiral. Not known if any fundamental (elementary) Dirac fermions exist in nature. Nothing forbids it, but since they can have large mass, unprotected by any symmetry, they are expected to be extremely massive if they exist, unless there is fine tuning. Actually, as far as we know, there is fine tuning.

• Start isospin. History: nuclear physics has a symmetry that rotates proton into neutron. Sounds weird (they have different electric charges), but the point is that the strong force, i.e. $SU(3)_C$ doesn't distinguish between ps and ns, though the electroweak force does. $SU(2)_I$ representations, for p and n.

• (Ended here. Continue next week, after midterm).

• Quarks. $SU(2)_I$ for u and d. Mesons: $\mathbf{2} \times \mathbf{2} = \mathbf{1} + \mathbf{3}$, and pions. Baryons: $\mathbf{2} \times \mathbf{2} \times \mathbf{2} = \mathbf{2} + \mathbf{2} + \mathbf{4}_S$. Now $SU(2)_{spin} \times SU(2)_{isospin}$.