Lecture 27: Higgs Dec. 5, 2013

In lectures 24-25 we considered a theory with a multiplet of scalar fields ϕ which transform as a unitary irreducible representation of a symmetry group G under which the Lagrangian is invariant, but possibly the lowest energy state (vacuum), about which we do perturbation theory, is not invariant. The vacuum expectation value ϕ_0 may be left invariant under a subgroup $K \subset G$, and the dimensions in the Lie Algebra $\mathfrak{G}$ of G which do not leave ϕ_0 invariant ($\mathfrak{G}/\mathfrak{K}$, generators of the cosets of G/K) give rise to massless scalar particles known as Goldstone Bosons.

In lecture 25 we considered theories with multiplets, whether scalar field ϕ or fermions ψ, which transform as unitary irreducible multiplets under a symmetry group G which we made local by introducing gauge fields taking values in $\mathfrak{G}$. We saw that this necessitated introducing massless vector particles in the adjoint representation of the group. Had we had more time, we would have discussed the problems of ensuring that the propagator doesn't give rise to unphysical states, which for Abelian theory was assured by the Ward identity. This requires the gauge particles to be massless, and when we considered the photon propagator, we argued that radiative corrections would not give the photons a mass because there are no massless scalar particles which could give a pole in $\Pi(q^2)$ at $q^2 = 0$.

But today we will combine our two ideas, and as the Goldstone bosons **are** scalar particles with mass zero, we may find a very interesting effect called the Higgs mechanism. This is the way we now understand the electroweak interactions, which, together with the color gauge theory of QCD, the strong interactions, forms the basis of the standard model of elementary particle physics.

Read Peskin and Schroeder, pages 689-696