Class #06 (Feb. 15) Reading Questions - Cosmic Onion, Chapt. 8

Summary: Chapter 8 gives an overview of the theory of the weak interaction and the development of the so-called electroweak theory. The weak interaction was first identified as the cause of neutron decay and the theory for this interaction is based on the similarities between the conversion neutron-to-proton (actually down-to-up quark) and neutrino-to-electron. Following the QED picture of a force exchanging boson, each of these processes must involve the generation of a charged object, called the W- and W+ particles. The binary "flavor changing" quality of the weak interaction suggests a mathematical description based on 2x2 matrices and this math construction suggests the existence of a third, neutral force carrier, the Z0. Glashow developed a formal mathematical model containing two charged and two neutral force carriers that encompasses both the weak and electromagnetic interactions. Weinberg and Salam showed that with the Higgs mechanism three of these bosons obtain mass and the fourth remains massless. From the experimentally determined relative strengths of the weak and electromagnetic interactions, this electroweak theory makes a prediction for the masses of the W and Z particles. Discovery of these particles at exactly the predicted masses provided dramatic support for the electroweak theory and Higgs mechanism. Despite the elegant theory, the weak interaction has some very odd features including the restriction to "left-handed" only neutrinos and the violation of mirror symmetry.

Questions:

1. In developing the theory of the weak interaction we group particles into pairs or "doublets" as follows: (u,d) and (nu,e). In terms of charge and spin properties, explain how are these two doublets are related to each other.

2. How does the Higgs mechanism "fix" the original unification of the electromagnetic and weak interactions?

3. What does the Weinberg angle theta_w give a measure of? Electroweak theory (with Higgs) predicts a W mass of m_W = 38.5 GeV/sin(theta_w) and a Z mass of m_Z=m_W/cos(theta_w). Do the numbers given in the chapter agree with these predictions?

4. What does it mean that the weak interaction does not respect mirror symmetry? How has this been demonstrated experimentally?

5. The standard model of particle physics describes the strong, weak, and electromagnetic interactions. The mathematical structure of this theory has the form: SU(3)xSU(2)xU(1). Explain what these symbols represent and why the SU(2) part actually carries the subscript "L".

Your Question: Please give a well-formulated question that you have regarding the material covered in this reading assignment.