8.811 Particle Physics
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Mid-term: There will be a mid-term on Thursday, Oct. 27, which has a weight of 20% for the final grade of this course. You are allowed to bring a one-page formula sheet with you for this mid-term.

Home works and the final term paper will have a weight of 40% each.

Final term paper: It is time for you to select an interesting physics topic and discuss with me about your final term paper on "How to establish a new important piece of physics". Possible topics includes but not limited to finding the Higgs, more Z's, lepto-quark, glu-balls, lepton number violation, neutrino oscillation, dark matters, anti-universe, toponia physics, SUSY, Techni-color, sub-quark structures, running coupling constants, mixing angles and CP violations, etc. You are expected to present your paper to the class in 35 minutes, including discussions.

What must be included, in this final written term paper, are:

1. The significance of this physics and what has been achieved so far,
2. How would you propose to do it: the source, the detector and the method,
3. Define the signal—how to select the signal,
4. Define the background —how to estimate & suppress the background,
5. Compute the signal to noise ratio to show what you propose is plausible,
6. Error (statistics) analysis and discussions for future improvements.

Assignment 4 (Refer to the lecture notes)
Due Oct. 25

1. In the d dbar-> W pair reaction, write out the interaction matrix element with the u quark exchange diagram and the interaction matrix element with the photon intermediate diagram explicitly to show that no cancellation is possible to avoid the divergence of the cross section.

2. In the same d dbar-> W pair reaction, instead of "inventing" the Z vector boson, we could have proposed the existence of a charge -4/3 d' quark and thus an exchanged diagram with this charge -4/3 d' quark. Show that cancellation is indeed possible to avoid the divergence of this cross section. Find the two equations which would determine the vector and axial vector coupling constants of the vertex W-d'-dbar. What are so unusual about these vector and axial vector coupling constants?

3. Explain why the proposed existence of a charge -4/3 d' quark would cause more divergence in one or more reactions and thus would be futile.

4. In the d dbar-> W pair reaction, compute the matrix element with the Z as the intermediate state (using the proper triple vector boson vertex) at the limit of the polarization vector of the W^+ being replaced by its 4-momentum divided by its mass at the high energy limit.

5. From the above, derive the two equations which determine the vector and axial vector coupling constants of the vertex Z-d-dbar.