Physics 5110 Homework 11 (due Apr 6)

March 28, 2012

1. This problem begins with the Feynman diagram you drew for problem 4c of Assignment 10.

   (a) Assigning the strength $e$ (from unification with electromagnetism) to each vertex in the Feynman diagram and a factor $1/(q^2 - m_W^2 c^4)$ to the virtual boson line, where $q^2$ is the square of the four-momentum transfer, estimate the order of magnitude of the total cross section in barns for neutrino-neutron scattering at low energy (say 10 MeV to be definite). (The argument goes very much like that of Williams, section 9.5, leading to the Rutherford formula. For the integral over $q^2$, just multiply by the square of the neutrino energy, 10 MeV.)

   (b) We are bathed by some $10^{15}$ electron neutrinos per m$^2$ per second from the sun with energies less than or of the order 10 MeV. Based on your estimate of the total cross section for this process, how many solar neutrino interactions with a neutron (resulting in a proton plus electron) occur in your body in your lifetime? (Order of magnitude estimate.)

2. Draw a quark line diagram for the reaction $p + n \rightarrow p + p + \pi^-$. 

3. To get a high energy in the c.m. frame, today’s accelerators use colliding beams. The Large Hadron Collider is currently producing head-on collisions of opposing beams of protons, each with 4.0 TeV (includes the proton rest mass). In the rest frame of one of the protons, what is the energy of the other proton (approximately)? (This tells you what accelerator energy would be required to achieve the same c.m. energy if the proton target were fixed.)
4. Williams 10.2