229C HW # 4 (due Oct 29)

1. Make a rough estimate of the amount of time a photon takes to leave the Sun. Use the Thomson cross section $\sigma = \frac{8\pi}{3}\frac{\alpha^2}{m^2}$, and the average density from the solar radius $R_\odot = 6.96 \times 10^8$ m and mass $M_\odot = 1.99 \times 10^{30}$ kg.

2. Find the recent solar neutrino predictions and data in John Bahcall, astro-ph/9808162. We would like to ask the following question: can the solar neutrino deficit be understood by abandoning the standard solar model calculations but by arbitrarily changing the normalization of the ^{8}B, ^{7}Be, CNO, and other individual components? (Let us call this "fudge factors.") This might be a reasonable thing to do if we are not comfortable with our own understanding in the dynamics of Sun, nuclear physics, plasma physics, etc. Note, however, that the normalization of *pp* neutrino shouldn't be changed because it is directly linked to the solar luminosity. Keep track of the uncertainties in the SuperKamiokande, Homestake and Gallex-Sage data throughout the problems.

(1) From the SuperKamiokande data, determine the fudge factor on the theoretical prediction of ^{8}B flux.

(2) Homestake (Chlorine) experiment is sensitive both to ^{8}B and ^{7}Be neutrinos (see Table 1). Subtract the scaled down ^{8}B flux as determined above from the Homestake data and determine the fudge factor for ^{7}Be neutrino. Neglect CNO and hep neutrinos in this analysis.

(3) GALLEX and SAGE are sensitive to all components of neutrinos. Subtract the contribution of *pp* neutrino from their data because this is directly linked to the solar luminosity and we cannot change it arbitrarily. Further subtract the ^{8}B neutrino and ^{7}Be neutrinos together with the fudge factors determined above. What is the fudge factor for the *pep* and CNO neutrinos combined?

(4) Discuss the results you obtained.

(5) Explain why the "just-so" scenario requires the Δm^2 of order 10^{-10} eV^2.